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Membership in Sustaining, Active, Associate or Student grades is open to any interested person according to his qualifications. Information about membership, technical activities and standards and test films for the industry is available from Society Headquarters.

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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Underwater Observation by Television

By DOUGLAS ALLANSON

Problems in underwater observation are outlined to permit an appraisal of the usefulness of television applied to this field. The advantages and limitations of television are presented and an attempt is made to draw up ideal specifications. A general purpose camera based upon this specification is described. The problems of lighting and application are discussed and future trends in design are suggested.

VISUAL OBSERVATION by indirect or remote means enables the observer effectively to place himself in a position where it may be inconvenient, dangerous or impossible for a man to go. Instruments by which remote or indirect observation may be achieved fall roughly into three categories:

1. Purely Optical: This includes apparatus making use of lenses, prisms or mirrors such as the telescope and periscope, and light channelling devices like the fibroscope.

2. Photographic: By means of still or cine cameras, visual images of events may be remotely recorded for future observation.

3. Electronic: This incorporates remote instrumentation and, in particular, television.

Each of the above categories offers advantages over the other two in certain particular aspects and for certain specific application. In the field of underwater observation the application of television (in conjunction with photography as a recording agent) opens up immense possibilities. The basic properties of television that are of such overriding usefulness in this field are threefold:

(1) The camera may be placed virtually anywhere and at any depth and the image it picks up may also be displayed virtually anywhere up to a distance of several miles from the camera.

(2) The image presentation is instantaneous and continuous. This enables working adjustments to be made to the camera position and its operating conditions as and when needed. It also enables operations so monitored to be continuously controlled.

(3) Any number of images may be presented simultaneously in different localities. This permits complicated operations to be controlled by a team of dispersed operators each of whom has an identical view.

Specific Applications of Television to Underwater Observation

It will be appreciated that, apart from pure observation, the great bulk of actual *work* underwater must be carried out by divers. One of the most rewarding uses of television in this new field, has been as an adjunct to diving.

When deep diving onto some particular location such as a wreck, it has been standard practice to first locate the object by echo-sounder and/or dragline and to moor the diving vessel, as far as can be ascertained, over the wreck. A weight known as the diver's "shot" is then lowered on the end of a line until it reaches the bottom. The diver then descends down the line. When he reaches the bottom he may or may not be able to see the wreck, depending upon the accuracy of positioning the ship. If he cannot see his objective he then connects a distance line to his shot rope and begins to explore the area within the radius of this line. If having done this he still cannot locate his objective, he must be brought to the surface, his shot must be repositioned, and the search continued.

Taking into consideration the short endurance of divers at depths in excess of 200 ft and the suspension of operations during periods of adverse tide or weather conditions, it will be realised that before work can even commence on an underwater object a considerable amount of time and expense is often devoted to the search.

Some submerged wrecks present considerable hazard to a soft-suited diver by reason of jagged metal work and unstable structure, so that even when they are found, much difficulty and danger may be encountered in reaching the part of the wreck where work is to commence.

A technique has been evolved, notably by Commander J. N. Bathurst of the Royal Canadian Navy,[1] and very successfully applied in which a television camera is shackled to the diver's shot rope, just above the shot weight. The two are lowered together to within viewing distance of the bottom. The parent ship is then moved slowly over the search area until the objective is seen. The maneuver is continued until the shot weight is seen to be directly over the required location. The weight is then lowered under continuous observation and the camera is brought to the surface.

The diver, and the Officer-in-Charge of operations have now had a preview of their objective. The diver knows in advance some of the hazards to expect and the tools he will require. His commander has been able to show him in more precise detail the work he wants done.

There are many specialists such as civil and marine engineers, biologists, geologists, oceanographers, salvage engineers who may be interested in specific features of some underwater problem or study. If the specialist does not dive, he has to rely upon the verbal report of a diver or upon photographic evidence in which the inevitable delay may be inconvenient. If a diver, under continuous telephone instruction, can maneuver underwater a small television camera, then the expert can see for himself with his trained specialist eye.

Some operations are of a complex nature involving the employment of several divers below, who may not be able to see each other. In addition, there may be a number of surface vessels of a specialised function, such as lifting vessels. When the action of all operators must be coordinated in a delicate task, it may be most advantageous if the Commander can see, by television, some critical part of the operation below the surface.

Television can be a most useful inter-

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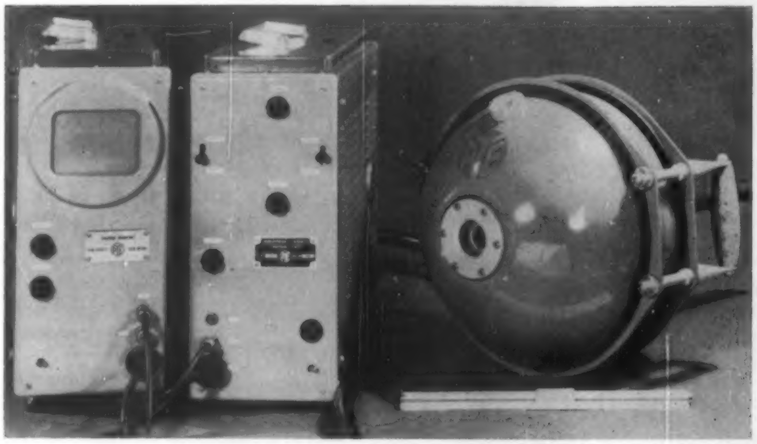

Fig. 1. Staticon camera in spherical chamber.

mediate process in underwater photography whether for scientific, commercial or entertainment purposes. The biggest technical problems in underwater photography are in the arrangement of lighting and in the estimation of exposure. In order to produce the best possible underwater motion pictures it has often been necessary to shoot twenty times the footage required to ensure sequences with the correct lighting and exposure.

Because a television image is instantaneously displayed, the optimum settings of the controllable factors can quickly be reached by observational adjustment. Moreover, drifts and variations in required settings can be continuously compensated. The actual photography is then simplified to a camera (still or motion-picture) recording direct from a monitor screen an image with an accurately known brightness and contrast ratio. It is possible, with a television system, to compensate artificially for poor contrast, as will be described later. Using this technique in cloudy water with excessive light scatter it is possible to produce, with an intermediate television process, higher quality film than can be obtained with direct photography alone.

By suitably increasing the bandwidth and the number of lines, and by devoting special care in the production of a camera tube and monitor, it is possible to approach very closely the definition of a good 35mm motion picture in a closed circuit television system. It is submitted that by using the technique of intermediate television, the making of underwater sequences for movie films can be done very much quicker, more simply, and less expensively; and shots which would otherwise not be attempted would be perfectly feasible.

In attempting underwater photography in color, as for example in scenes from the Walt Disney Production *20,000 Leagues Under the Sea*, the problems of lighting and exposure are considerably increased. Color film has narrower latitude than monochrome so exposure must be more exactly assessed. Also water absorbs different wavelengths of light to a different degree. With sunlight illumination from the surface, about 50% of the red component is absorbed in the first 6 to 10 ft and at greater depths there is an even greater preponderance of the green-blue wavelengths. The degree and selectivity of the absorption varies in different parts of the world and at different times in the same locality. In one instance out of 600 exposures on color film only 25 were reasonably correct.

It will be seen, therefor, that the task of making underwater motion pictures in color is far from easy. Color television systems have separate amplifiers for the red, blue and green components of the signal and separate individual adjustments of gain, setup and gamma can be made for each color while the image is under continuous observation. While it cannot be denied that an intermediate color television process would add considerably to the complexity of the apparatus for film making, it is submitted that the instantaneous monitoring facility of the picture coupled with continuous control of the variables would ensure the optimum picture quality at all times and minimize the need for retakes.

Use Without Divers

It may sometimes be more economical to use television for observation purposes than to employ a diver for work in clear waters. In cases where it is practicable to use either, the decision will be largely one of economics and television, especially if hired, may well be cheaper. On the other hand television really comes into its own in the underwater application in circumstances where it would be highly dangerous or completely impossible to send a diver.

Because a television camera can be made of small dimensions it can be housed in a chamber of immense strength. There seems to be no practical reason why a television camera should not one day explore the most profound ocean depth and present to the eyes of man the floor of the Phillipine Trench eight miles down. Certainly present-day techniques have sent cameras down with ease to depths far in excess of those obtainable with normal diving practice.

At a depth of 300 ft a soft-suited diver is able to remain there and work for only thirty minutes, and then only if he is experienced, very fit, and the water is substantially free from currents. This is normally regarded as the greatest working depth for divers, although the record depth for a soft-suited diver is well over 500 ft. A television camera has unlimited endurance. It can work round the clock and in weather too rough for diving.

The study of the behavior of certain dynamic surfaces and devices under actual working conditions can considerably speed up design. Examples of such are trawled fishing gear; ships' propellors and rudders; the planing surface of speed boats; paravanes; the hull, superstructure and hydroplanes of submarines. Television enables an eye to be placed in the water to observe directly the action of devices of this nature while in motion through the water. The camera may be lashed securely to a strategic position on the ship's hull or it may itself be trawled fitted to a framework with suitable planing surfaces.

Certain operations may be too hazardous to risk the life of a diver and a television camera may be used if its loss is financially acceptable. For some applications such as the observation of underwater explosions the destruction of the camera is inevitable and it then simply becomes a matter of regarding the camera as an expendible item.

A camera left undisturbed on the sea bottom for a period of time becomes an unobtrusive observer of marine life and a valuable tool in the service of marine biologists.

The considerations set forth above suggest the wide variety of tasks that present themselves in this field and the great versatility of television as a tool in the accomplishment of them.

Camera Pickup Tube Design

Only two currently available pickup tubes merit serious consideration, namely the image orthicon and the vidicon or Staticon. The latter tube is most appealing by virtue of its small size, its simple associated circuits and its low cost where expendability has to be considered. It is very tempting to use the vidicon or Staticon and excellent results can be obtained with this tube in clear shallow waters where there is considerable penetration of sunlight. A camera using a Staticon is shown in Fig. 1 together with its control equipment. However, when artificial light has to be used, and especi-

ally in conditions of cloudy water, supreme sensitivity is an overriding factor in the range and usefulness of the camera. This matter is considered in detail later. The image-orthicon pickup tube achieves a sensitivity sufficiently in advance of the vidicon or Staticon to render it an almost inevitable choice for a camera of universal application. In addition, due to secondary redistribution effects, the characteristic picture from an image orthicon exhibits an enhanced differentiation of outline. This is of considerable advantage in helping to distinguish shapes in a picture of very low contrast.

Optical Requirements

A properly focused optical image must be presented on the photo cathode of the image orthicon. In order to make use of the minimum amount of light it is considered that the most important feature of the lens is that it should have the widest possible aperture. Second only in importance to this, is the requirement for a lens having the widest possible field of view. Of necessity there must be somewhere along the optical path a transfer of the light from water to air and hence a corresponding reduction of viewing angle proportional to the difference of the refractive index of the two media. This means that to achieve an angle of 70° in water a 93° angle lens is required, if a flat window is used. By employing a curved window a cone of light can be admitted from water to air with no change of angle and if the window glass is specially shaped it is possible for an increase of angle in water to be achieved. However, if the window glass is curved it becomes, in effect, part of the lens system and the curvature of the window must be computed in conjunction with a specially designed interior lens to avoid distortion and aberrations. This becomes a costly, specially designed system and makes the facility for changing lens angle difficult to arrange. A curved window glass is also difficult to design against extreme pressure and to seal effectively. It would appear that the advantage of increased angle obtainable with a window glass of specially computed curvature is outweighed by the cost and difficulties involved. A standard commercially available lens and flat window have given excellent results in practice.

It will be shown later that if a cylindrical case is employed it is convenient for other reasons to offset the pickup tube to one side of the camera. This lends itself very conveniently to the employment of a turret, remotely operated, holding two or more lenses for a choice of viewing angles. This has been found a worth-while feature, since if a very wide angle lens is used for searching, a smaller angle can be used to advantage when making a close examination of an object ten or more feet away.

The aperture of each lens must be capable of adjustment from the surface and a remotely controlled reversible motor provides an obvious method of doing this. In cloudy water when the range is severely restricted the conditions obtain where objects are being viewed at distances of a foot or two with the lens at wide aperture. The resulting short depth of focus makes it highly desirable to have some means of adjusting the optical focus from the surface. For ease of operation a servo-controlled system is desired for this function rather than a switched motor. In addition, the control knob may be calibrated in range and thereby afford a guide to the distance of the object being viewed and therefore to its size.

Before leaving the subject of optics, a mention should be made of the allied problem of directing the camera to look in any desired direction, or in studio parlance, panning and tilting. An ingenious attempt has been made to solve this problem by purely optical means. A servo-controlled periscope arrangement has been developed that is fitted to a camera normally hanging vertically downwards. By tilting and rotating prisms it is possible to view at will any part of the complete hemisphere beneath the camera. At first sight this would seem to offer an elegant solution to this problem but unfortunately it is attended by a number of serious difficulties.

(1) The lighting is difficult to arrange. If the complete hemisphere is artificially illuminated the fogging due to backscatter is a serious problem. The best form of lighting would seem to be a beam which moves and coincides with the viewing direction at all times, a difficult mechanical problem.

(2) Of necessity, the first element in the optical system must be housed in a transparent dome projecting beyond the camera casing. This is most vulnerable to damage.

(3) Practical periscopes made so far have suffered a rather serious restriction in aperture.

(4) Image orthicons used in the vertical position are prone to target damage.

A camera with a periscope attachment, used over an extended period side by side with one having a simple lens, had the advantage of a more flexible viewing direction but proved inferior in other respects, particularly in range.

It would seem that the problem of directing the camera is best solved by making the camera itself as small and compact as possible, retaining the simple wide aperture optical system and attaching the whole camera to a separate panning and tilting device. This is a more versatile arrangement leaving the camera adaptable to uses where the panning and tilting facility is not required. Such an "Underwater Vehicle" of an elaborate and versatile design has already been in operation.[2]

Circuit Arrangement

It is not the purpose of this paper to describe in detail the circuits of a typical television system. It is assumed that the reader already has a working knowledge of the principles of television engineering or that he will avail himself of one of the many excellent standard textbooks on this subject. The factors required in a television system specifically adapted for underwater observation are reliability, ruggedness, compactness, simplicity of operation and ease of maintenance; and such a system should be inexpensive.

In the search for simplicity, various departures from normal practice have been considered — such as spiral scanning. In all such methods so far examined, the attractive features are outweighed by attendant complication. The standard interlaced scanning system could be used with a much reduced number of lines without loss of definition in resolving many underwater scenes. This would enable a considerable saving in bandwidth and circuit complexity, but in clear sun-lit water the clarity of the optical image is at least equal to the definition of the standard broadcast system.

Adoption of the standard 525/625 line system has the advantage that there are available standard production monitors which are inexpensive and reliable and that commercially available test apparatus can be used.

An underwater television system must consist of a certain amount of "circuitry" on the surface and a certain amount under water connected together by a multi-core cable. There is a choice of location for a considerable amount of circuit components, and it is desirable to house as much as possible of the electronic circuit on the surface even if the whole system is thereby made somewhat more complicated. This reduction to the minimum of the components actually in the camera has the following advantages:

(1) There is less to go wrong and fewer working hours will be lost in hauling out the camera to repair a fault.

(2) The camera is made less expensive to replace if lost.

(3) The camera can be made smaller and lighter to facilitate suspension and to ease the problem of panning and tilting.

(4) Less heat is generated inside a case which cannot be ventilated. This is important in tropical waters and when testing out of the water.

The limit to the ideal of removing camera circuits to the surface end of the connecting cable must be set when this process results in a deterioration of picture quality or efficiency, leads to excessive circuit complication, or adds considerably to the power requirements. In general it will be necessary to locate in the camera the horizontal scan generator, at least two video amplifier valves

and possibly at least one valve for target blanking.

The whole of the remaining electronic circuits could be housed in one container on the surface but if this includes a picture monitor it will tend to be somewhat large and heavy. In view of the usefulness of several picture displays a convenient grouping of the surface apparatus is to have: (1) one box containing the power supplies, synchronizing pulse generator, main video amplifier and all the ancilliary camera circuits, and delivering a complete video waveform with synchronizing pulses; and (2) picture monitors in number and screen size as required.

Such a subdivision of units yields a convenient size and weight for handling and a minimum amount of interconnecting cables. They can all be packaged for universal air freight and can be loaded into small boats.

Camera Cable

The camera must be connected to the surface by an electrical cable containing sufficient isolated conductors to carry all supplies and control facilities to the camera plus power for an underwater lamp and certain other additional facilities as may be desired. This cable must be completely pressure tight against water at all working depths and its outer sheath sufficiently robust to withstand considerable abrasion.

The camera must also be connected to the surface by a suspension cable sufficiently strong to hold many times the weight of the camera. In early underwater apparatus the camera was large and heavy and separate suspension and power cables were used. This severely restricted the speed with which the camera could be raised or lowered and introduced an additional hazard in complex operations where large numbers of other cables were involved.

With the introduction of the small light-weight camera it becomes feasible to combine the power cable with a concentric outer lifting cable consisting of a woven sheath of hemp or nylon. This has an outer protective skin of tough polyvinyl chloride. With a cable of this nature it has been found possible to lower and raise the camera at speeds of 180 ft/min, about ten times faster than is possible with separate cables.[3]

An important requirement is the facility for quickly and easily detaching the cable from the camera. This enables the two to be transported separately and it also permits various lengths of cable to be used as circumstances demand.

A detachable cable necessitates a watertight and pressuretight plug and socket. During operations off Elba in the salvage of the crashed Comet Air Liner an early camera constructed without a detachable cable was flooded when its cable was fouled and cut by a steel hawser. Water entering the cable through the puncture in its sheath was forced down into the camera. A recurrence of such a mishap would be prevented by employment of the underwater connector because the camera section of this connector would consist of a plug which effectively forms the pressuretight bulkhead. A cable fulfilling this specification has been developed by British Insulated Callender's Cables Ltd., London.

Underwater Illumination

Illumination, whether for television or cinematography, presents special problems in underwater work at depths beyond which the surface light is lost. A television camera, like the cine camera, is dependent upon light and water clarity for range of vision, but it is more flexible in this respect due to its superior light sensitivity and contrast ratio and to the fact that the information it gives is instantaneously presented so that adjustments can be made continuously to match changes in conditions.

Light transmission through water is governed principally by the absorption characteristic of the water and by the scattering effect of the water molecules and small particles in suspension. The absorption is greatest at the red end of the spectrum. With bright sunlight penetrating through clear sea-water the red component is extinct at about 50 ft, yellow at 200 ft, while green-blue light has the greatest penetrating power. Light has been recorded on a photographic plate at a depth of 3,250 ft with an exposure of 80 min. The greatest reliable depth at which useful television pictures can be obtained without artificial illumination is about 200 ft.

The scattering effect of the water molecules and fine particles is similar for all wavelengths of visible and ultraviolet light. Scatter is less in the infrared region but here absorption is too great to allow the use of infrared light to take advantage of this. In general no worth-while advantage is gained by using filters or a light source of one particular wavelength, although improvement has been obtained in isolated cases. For instance, during experiments in exceptionally clear water off the west coast of Scotland at a depth of 350 ft a consistent improvement of range of almost two to one was obtained using a mercury-arc source with filters as against an incandescent lamp of the same power consumption. Subsequent experiments elsewhere have failed to show any substantial advantage in the mercury arclamp.

Consider a lamp illuminating both an object and some scatter particles close to the lamp. Let d be the ratio:

$$\frac{\text{distance lamp to object}}{\text{distance lamp to scatter particles}}$$

then the intensity of illumination at the object would be $1/d^2$ times the intensity of illumination of the scatter particles. Allowing an absorption factor of 50% and assuming the object might reflect 50% of the light falling upon it then the intensity of illumination of the scatter particles will be $4d^2$ the intensity of the light reflected by the object. It will be seen then that the scatter particles in the water between the lamp and the object will be very highly illuminated by comparison with the object itself.

The effect of light scattering from the forward light beam is similar to the effect from car headlamps in fog, and results in a reduction of contrast. Television technique provides a facility for partially offsetting this effect. By increasing the gain of the amplifier and by turning the setup setting down, it is possible to depress the waveform so that the pedestal due to the flood of scattered light lies below black level. This facility gives television a considerable advantage over photography and it has been proved in practice to have a greater range than the human eye in conditions of bad light scatter.

However, there is, of course, a limit to the artificial restoration of contrast and in all cases a substantial increase in range can be achieved if efficient use can be made of daylight filtering down from above. For this reason it is of considerable advantages to use a pickup tube of highest sensitivity and a lens of wide aperture. An image orthicon camera using a lens of $f/1.9$ will give reasonable pictures in clear sea-water in sunlight at a depth of 180 ft while sufficient light penetrates to 350 ft to enable vague outlines to be seen. A camera of this sensitivity can in general be handled by a diver without the additional encumbrance of a lamp.

For reasons which are difficult to explain theoretically it has also been found that when artificial light is used, an in-increase in range can be obtained if the lens aperture is opened up and the light source correspondingly dimmed.

A considerable reduction in the amount of scattered light entering the lens can be achieved by placing the light source forward of the lens to reduce its distance from the object and to increase its distance from the lens and by concentrating the light into a beam. Figure 2 shows the optimum practical position for a light source attached to the camera. The most efficient light beam will be that which illuminates the minimum volume of water and therefore will have the smallest angle necessary for coverage of the area seen by the camera lens. Due to parallax this will be somewhat larger than the lens angle and will be dependent on the object distance. To take up this variation and to match angles in a multi-lens camera it has been found a worth-while advantage to incorporate a focusing lamp so that its angle can be adjusted to correspond with that of the lens in use.

That the particles in suspension are theoretically too large to offer any advantage from a color selective light source has in general been borne out in practice. Many different types of lamp have been tried with the conclusion that the most useful general purpose source is an incandescent lamp of about 150 w with a remotely focused beam and with dimming facility. Provision should be made for fitting a more powerful lamp for use in clear water where the range obtainable is exceptionally great.

For specialized work and in particular for still and motion-picture photography where the aim is artistic perfection and the site is specially chosen for minimum technical difficulty, the best results will be obtained by deploying a number of lamps and reflectors at selected positions near the subject. However, in the more utilitarian and scientific employment of underwater television it will be generally used in positions of difficult access and manipulation will be grealty simplified if the lamp is attached to the camera. A number of lamps grouped around the camera tends to reduce regions of shadow, but the very large increase in the scatter area of the forward beams more than offsets this advantage and in practice superior results have almost always been obtained with one lamp only.

A further consideration against the employment of a multiplicity of lamps is the necessity to streamline the whole assembly as much as possible to reduce the risk of getting the camera snagged on obstacles in the water. The camera design shown in Fig. 3 would seem to offer the most practical positioning of the lamp in consideration of the foregoing factors.

Camera Casing and Mechanical Design

For all applications of underwater television, with the exception of color, the electronic part of the camera is required to perform the same function. The requirement of the casing and its fittings however will vary with application. An ideal arrangement therefore is to have an internal framework containing the pickup tube, the optical arrangements and the electronic components universal to all cameras. This unit, termed the "camera head," can then be fitted into any one of a variety of cases according to operational requirements. Such cases may consist of:

(1) A light, low-pressure container fitted with handles intended to be maneuvered by a diver.

(2) A chamber of thick steel with a specially designed armour-plate window for use at great depths.

(3) A general purpose light alloy chamber for depths down to about 3,000 ft with facility for the attachment of a lamp and fins or capable of being attached to ancillary units such as an underwater vehicle or the arm of a grab.

By the use of correctly designed fins a camera may be trawled in a stable attitude over the bottom by a vessel moving at speeds up to two knots. This facility was used with great success during the search for the Comet aircraft wreckage off Elba in 1954.

An important factor in the mechanical design of the camera is its ability to withstand shock. The image orthicon is a delicate instrument and it must be so cushioned that it and the associated components will not suffer damage when the camera hits submerged obstacles or crashes against the side of the ship when being launched in rough weather.

Accessories

Wherever possible the whole equipment should be run from the local power source. The power supply on ships tends to vary widely in voltage and frequency and often it is not stable in either. The input transformer, therefore, should be tapped to accommodate wide ranges in supply voltage and the B+ should be automatically stabilized. A portable petrol generator should be available to power the equipment where there is no alternative suitable supply. An attempt should be made to restrict the total power consumption to one kilowatt since a generator of this capacity is easily portable and can be packaged for international air freight.

A most valuable adjunct to a television system for underwater is a means of making a photographic record from the screen either by cine or as a succession of still photographs. This enables fleeting glimpses of objects to be preserved for more leisurely identification. It also permits scrutiny by experts at a more convenient place and time. A number of successive photographs joined together can give a more comprehensive panoramic picture.

For this purpose it is best to have a separate monitor specially adapted for photographic recording. A hood extending in the form of a cone from the monitor screen may be arranged to support a camera. The camera shutter should be pushbutton operated by an observer seated in front of another monitor. Alternatively, a viewing slit can be arranged in the hood and the same monitor used for observation. It must be borne in mind that a photograph obtained in this manner may be used for measuring off relative distance and angles to determine certain dimensions of underwater objects. In order to ensure a reasonable degree of accuracy in such measurements, an attempt should be made to keep the total geometrical distortion of the monitor and camera raster to within ½%. This includes scan linearities and aspect ratio.

An Underwater Television Camera Chain

The salient features of an underwater camera chain will now be briefly

Fig. 3. Camera in universal chamber.

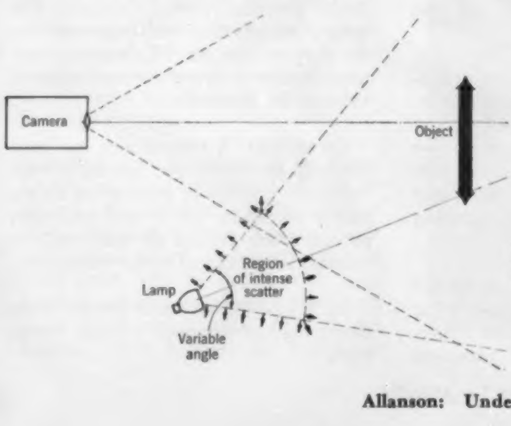

Fig. 2. Optimum positioning for lamp attached to camera.

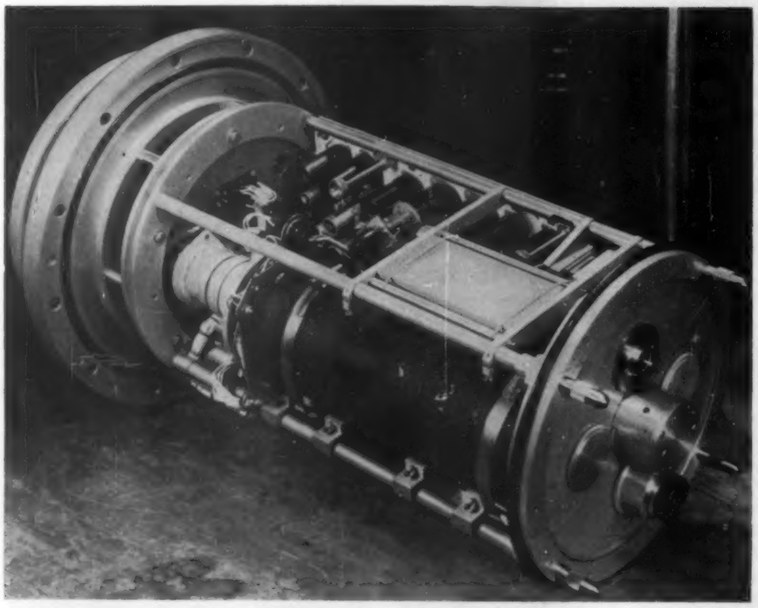

Fig. 4. Camera head attached to backplate of universal chamber.

described to show how some of the foregoing requirements have been embodied in a practical design. The camera is in quantity production and it is based on a prototype successfully used to locate the wreckage of the Comet aircraft off Elba in 1954.

Physical Parameters: The overall length was governed by the length of an image-orthicon tube with a certain amount of cabling behind and a simple optical system in front. The components that had to be contained within the camera were weighed and a factor added to give an approximate figure for the weight of a light hand-held chamber. From this weight the volume of displacement for for one pound bouyancy in water was worked out. With the minimum length and the volume thus determined, a simple calculation established the diameter of a cylindrical chamber which, when containing the camera head, would just float in water.

It was found that when the image orthicon was offset to one side, this diameter was sufficient to permit the employment of a four lens turret and sufficient space was left for a reasonable assembly of the remaining components.

The next step was to distribute the heavier components within the camera head framework to give a low center of gravity, and to make the camera adopt a horizontal attitude longitudinally and transversely when submerged. Stabilized in this manner the minimum amount of effort is required by the diver when handling the camera. The basic physical parameter was now established for the smallest possible image-orthicon camera suitable for handling by a diver. This being the most critical requirement for size, volume and weight, the camera head so evolved would be suitable for use also in other types of chamber.

Figure 4 gives a view of the head attached to the back plate of a deep-sea, universal-type chamber. It will be seen that the head is built between and supported by tubes of stainless steel fixed to the backplate. The whole weight of the camera head is supported from this end and the tubes give sufficient resilience to protect the camera components against shock. Optical focusing is adjusted by sliding the image orthicon and its coil assembly. This is mounted on a carriage supported by two of the stainless-steel rods and is driven by a servo-controlled motor.

The head may be quickly dismantled into three major units as illustrated in Fig. 5. The turret assembly contains the motor and gearbox for operating the iris of the taking lens and the motor and gearbox for driving the turret. Up to four lenses may be accommodated on the turret but it is recommended that one blank station is retained for the purpose of capping.

The chassis assembly on the left of Fig. 5 houses the horizontal scanning generator, target blanking mixer and amplifier, beam cutoff relays for scan failure, and the video preamplifier. The frame at the rear contains the image-orthicon coils and carriage with its driving motor and gearbox and the various interconnecting plugs with their cabling.

Camera Chambers: Figure 6 shows the camera in the hand-held case being maneuvered by a diver. The cable emerging from the center of the backplate snakes conveniently under the diver's arm.

The camera housed in the universal chamber suitable for depths down to 3,000 ft is illustrated in Fig. 3. It is seen that the chamber is supported in a stirrup. The outer sheath of hemp or nylon lifting rope is clamped in the center of the stirrup and the camera can be set at any angle with respect to the horizontal. The remotely focused lamp housing is placed at the optimum position for reduction of back-scatter and is supported by two fins. The angle of the lamp with respect to the axis of the camera is also adjustable. The two fins stream back from the lamp to the camera and are shaped to stabilize the camera in a current. They are so set that the camera trawls naturally backwards. This direction reduces the risk of breakage to the camera or lamp windows by striking submerged objects and the shape of the fins and of the leading edge of the stirrup is such as to enable the camera to ride over submerged obstacles.

Figure 7 shows the back of the universal camera chamber in its latest form using the self-supporting cable and underwater connector. The cable passes through an exponential cleat in the supporting stirrup designed to prevent damage to the cable at this point. Here the outer supporting rope is clamped and the inner electrical cable passes through in a loop to the water tight connector in the center of the backplate.

A rod or probe can be fitted into the two clamps on top of the camera (Fig. 3) so that it projects up to 12 ft forward of the window. This provides a most useful monitoring object as the camera is being lowered through featureless water and the range of visibility can be continuously checked as the camera descends, by noting the length of probe that can be seen. A piece of cloth tied onto the probe gives a useful indication of the direction and speed of camera movement through the water.

The probe, lamp, fins and stirrup can be removed to enable the camera to be fitted to other apparatus. An interesting feature of the lamp is that it uses a bulb of small physical dimensions, which is water cooled, developed specially by the British Thomson Houston Company. The lamp housing is filled with fresh water for this purpose. The small dimensions of the lamp enable a better concentration of beam to be obtained.

Control Unit: A control unit has been specially developed for operation with this camera. It can be powered by an a-c supply of 90 to 250 v and generates stabilized B+ voltage for itself and the camera. Incorporated in the control unit are:

(1) A blocking oscillator divider chain producing the standard 525-line waveform.

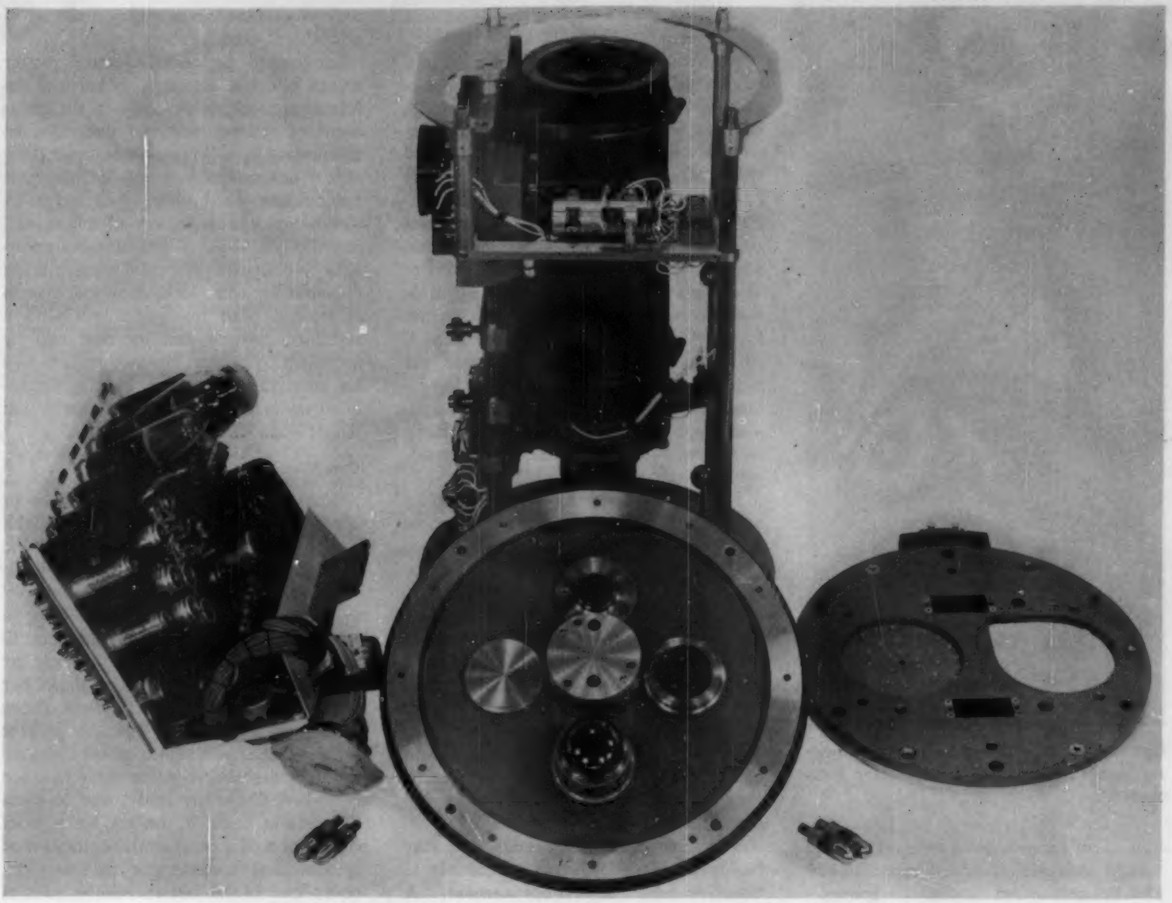

Fig. 5. Breakdown of camera head.

(2) The main video amplifier with blanking and synchronizing pulse insertion stages.

(3) The vertical sweep current generator for the camera tube.

(4) The current stabilizer for the image-orthicon focusing coil.

(5) The amplifier for driving the optical focus servo motor.

(6) All the setting up controls for the camera tube and its scanning generators.

(7) An oscilloscope for monitoring the video waveform and for fault tracing.

(8) A meter for monitoring voltage and current supplies and for fault tracing.

The control unit is housed in a rugged compact case of the same size as the associated picture monitors which are of a standard broadcast type using 14-in. rectangular tubes.

Cable Delay: A problem arises when lengths of many thousands of feet of camera cable are involved. The delay of the video signal reaching the control unit with respect to the initiating horizontal drive pulse may be considerable. The solution adopted is to send the drive pulse down one coaxial line to the camera where it starts the horizontal

Fig. 6. Diver with camera in hand-held case.

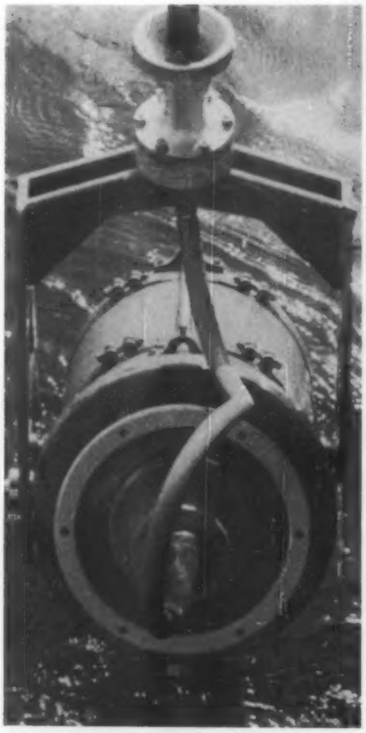

Fig. 7. Rear of universal chamber showing cable clamp and underwater connector.

scan. This pulse is then returned to the control unit via a second coaxial line. The delayed pulse is used to generate blanking, clamp and synchronizing pulse waveforms. The video signal reaches the control unit via a third coaxial line with precisely the same delay for all lengths of camera cable.

Future Trends

Two of the major problems to be tackled in order to extend the usefulness of underwater television are lighting and mobility.

Much of the work attempted in dock and harbor areas is restricted by the turbidity of the water which severely restricts the range of vision. Development of techniques to extend vision in this kind of water will pay large dividends. For example, the displacement of the muddy water by clear water which may be trapped in a rigid or a flexible container or may be freely injected into the region in front of the camera, or the use of chemicals to precipitate the suspended particles in the water between camera and object.

In early operations the camera was hung from the parent ship and allowed to take up an attitude that could not be controlled in azimuth or elevation except to a small extent by means of control wires slung at bow and stern of the ship and at either side. To move the camera the entire ship was moved foot by foot by hauling on its anchor cable. Such a process was most difficult and tedious.

A partial solution affording a certain amount of control is the use of the rotatable optical system discussed above. A much more complete and versatile instrument is the underwater vehicle called the "Hydrobot," developed by the American Machine and Foundry Company,[2] which has been used in conjunction with the underwater camera chain with great success. Further development along these lines will provide the ultimate solution of the mobility problem, in the form of a carrier capable of remaining a steady controllable distance from the bottom, capable of moving in any lateral direction at will, up to a speed of 6 knots, and supporting the camera with its lamp in a frame which can be remotely adjusted in azimuth and elevation.

In surveying the greatest ocean depths a specially developed casing and window will be required to withstand a pressure of $8\frac{1}{2}$ tons/sq in. The insulation of the lower sections of the cable will have to remain effective also at this pressure. Up to nine miles of cable will be involved, calling for submerged repeater amplifiers at several points in the cable. Development for the greatest depths should not be technically difficult but since no immediate financial return would attend its use, such apparatus will probably have to await sponsorship by a research organisation.

The television technique is today highly developed and it is difficult to visualize substantial improvements. A vidicon or Staticon-type tube with the same or better sensitivity than the present image orthicon may be possible. Such a tube would lead to a considerably smaller and less complex camera with the attendant advantages.

There are advantages in the adoption of a spherical design of camera chamber. Its pressure resistant properties are better and certain improvements in handling and maneuverability are obtained. A spherical camera using a Staticon tube may be seen in Fig. 1. This is intended for manipulation by a diver in water where the illumination is good.

Color is required only when television is used as an intermediate process in motion-picture and artistic production or for certain very limited scientific work. Below the immediate surface layers the color range in daylight is restricted to a narrow green-blue band, and for general work the additional facility of color is not worth while. For special applications, however, the system having the outstanding features of simplicity, low cost and producing excellent pictures is the single-tube, frame-sequential system employing a motor-driven filter disk first demonstrated by J. L. Baird and later developed by C.B.S. in America and Pye Limited in England. This would seem to be the obvious system to adopt and no difficulty should be experienced in adapting it to underwater work.

Stereoscopic presentation of underwater scenes offers advantages in certain observation work, principally in the judgment of relative size and distances. In attempting to identify objects under difficult conditions of lighting and angle, a three-dimensional view often helps. A stereoscopic presentation of plant and fish life would be of considerable assistance to biologists. A special camera is not required for this work. A simple system of mirrors used in conjunction with a standard camera and monitor can be arranged to present the two images side by side on two halves of the screen. Such an arrangement was made by the Royal Naval Scientific Service.[4]

Conclusion

The use of television for underwater observation is a rapidly developing field. Cooperation between seamanship, the art of diving, and television engineering is still in the process of forging a powerful and flexible new tool and evolving a technique in its use. It is as important to recognize the limitations of this new art as it is to extoll its virtues. This paper has touched only the fringe of this field. It has attempted a threefold task, to present some of the immediate possibilities of the new medium, to guide those who are interested to further study, and to show the present state of the art by a brief description of a commercial camera that is achieving considerable success. The ocean bed is the last remaining part of the earth's surface withheld from the service of man. For better or for worse he will one day have free access to it. The long-term vision conjures up pictures of mines tapping the mineral wealth to be found there and vast areas of the ocean floor cultivated to grow new kinds of food. When that day comes television will have helped to bring it.

Acknowledgments

The Author wishes to thank the Directors of Pye Limited for their permission to publish this paper and thanks are due in particular to the Technical Director, B. J. Edwards, for his interest and encouragement. Invaluable assistance and information were supplied by D. R. Coleman of the Pye Underwater Division.

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Discussion

George Gill (Gill Southern Associates): Could you give additional information on the lighting sources?

Mr. Allanson: We have done quite a lot of experiments with lighting under water and in general we find there's no advantage to be gained by using light of any particular color. The chief trouble with lighting is the backscatter of the light from the water particles or from fine mud suspended in the water. These particles are so large that all visible light is scattered by them. Infrared light is scattered less but unfortunately you can't use infrared because it is absorbed by the water. So we just use a simple, ordinary incandescent lamp and we found also, although it's difficult to explain, that if you use the minimum amount of artificial light and the widest aperture lens you get better results than if you increase the light. So we use a simple 150-w incandescent lamp for short and medium ranges and 250 w or larger for extended range in clear water.

George T. Keene (Eastman Kodak Co.): What is the effective radius of photographic visibility using one of these lights and your underwater camera?

Mr. Allanson: The visibility range depends entirely on the clarity of the water. There's a theoretical limit to how far you can see in air and there's a theoretical limit to how far you can see in clear water. I believe in air it's something like 300 miles. In water, the theoretical limit for distilled, clear water is about 300 ft. The greatest range we've achieved so far in clear sea water is about 45 ft. In generally clear water the average range is about 20 ft, but you can get water so foggy that you can't even see 6 inches. It depends entirely on the mud content of the water.

Werner Freitag (New York University): Could you tell us please what kind of lens you used, how wide an angle lens and how fast it was?

Mr. Allanson: Yes, the lens we used was 90° angle in air. In front of the lens we have a flat glass plate so we lose angle due to the refractive index of water, making the angle in water only about 70°. The lens is $f/1.9$.

Frank N. Gillette (General Precision Laboratory): Was there any correction made in the lens system for the effect of the water?

Mr. Allanson: No, if you use a flat glass plate with optically flat sides you don't need any correction at all; it's only if you start to use curved windows that you need lens correction. If you use a curved window you can defeat this reduction of angle due to the refractive index of water, and you can achieve the same angle in water as you do in air. You can even go one better and have a wider angle in water than in air, by use of a specially curved window glass. But then the window glass becomes part of the lens system and you have to have a specially designed element, as the lens proper. We found that it's cheaper and almost as good to use standard 35mm lenses.

Projecting 16mm Film With Large Reels

By J. S. CHANDLER

The concept of "effective weight" is developed as a means of rating reels according to their relative film-damaging potential. Useful relationships between size, capacity, stiffness, weight, and effective weight are presented for all 16mm reel sizes. The importance of a large ratio of core diameter to outside diameter for the reel is stressed. Some standardization proposals and design features of the projector for use with large reels are suggested.

When a projector is started, the tension that is created in the film as the reels are set in motion may be many times greater than the normal tension that obtains during steady operation. The result is frequently cinch marks on the film and sometimes even stripped sprocket holes. In the past, the situation has been more annoying than serious in 16mm projection, partly because the reels were small and partly because the greatest forces are exerted when the empty take-up reel is started, and hence the damage was largely confined to the leader, which could be replaced readily. Now, with the increasing popularity of large reels for television purposes and the growing custom of using short sections at a time, which involves stopping and starting the partially projected reels, the resulting damage to the film is becoming a matter of concern. The situation is aggravated further by the circumstances that the projector is perforce started and stopped at about the same places each time, and thus the damage is concentrated in certain regions.

The forces required to change the rotational velocity of the reels during starting and stopping increase as the size and weight of the reels are increased. Part or all of these forces may appear as added film tension; or the film may become slack momentarily, resulting in severe shock stresses when the slack is taken up. It is the purpose of this paper to show how the film damage can be reduced despite this circumstance. Data are given only for 16mm reels because such reels are now used in some television stations. The same principles can, of course, be applied to 35mm and other reels.

Effective Weight

Since the reel with its film load is a rotating system, it is customary to deal in the rotational terms of torque, angular acceleration, and radius of gyration, together with the mass. For this discussion, the concept of *effective weight* will be introduced so that it is necessary to deal only in the linear terms of film force and film acceleration. This concept offers a simple means of visualizing the operation and of analyzing the magnitude of the film forces involved. The effective weight may be thought of as that weight which, if attached directly to the film and supported without friction on a horizontal table (Fig. 1A), will require exactly the same film force, T, for a given rate of change of linear film velocity (i.e., acceleration) as does the actual reel with the film wound to the radius, r (Fig. 1D), and of specified total weight, W, and radius of gyration, k.

By definition, the radius of gyration, k, about the center of rotation is that radius at which the entire weight, W, may be concentrated in a thin hoop (Fig. 1C), and will be exactly equivalent mathematically to the actual rotating body. This value of k is obviously dependent upon the actual distribution of the weight in the reel and the amount of film on the reel. A practical method of determining the value of k for any existing reel will be presented in a later section. However, instead of considering the entire weight, W, to be concentrated at the *radius of gyration*, k, some different fictitious weight may be considered to be concentrated at the *film radius*, r, so as to be mathematically equivalent to the actual reel and film of weight W. This fictitious weight is then the effective weight, W_e.

On looking at Fig. 1E, it will be seen that the reel has been represented by a simple, weightless lever pivoted at its lower end and with the entire weight (W) concentrated in a point at a distance from the pivot equal to the radius of gyration (k). The film force (T) acts at radius r, and it is desired to replace the weight (W) by the exactly equivalent weight (W_e), located at radius r. The weight W_e is to require the same force, T, for a given film acceleration measured at radius r as does the actual weight, W. This equivalent weight is then the *effective weight*. However, on the one hand, the force of acceleration actually applied to the weight, W, is reduced to r/k times the film force, T, applied at radius r; and, on the other hand, the motion and acceleration of the film at radius r are r/k times that effective at weight W. Because of this double effect of lever ratio, it is found that

$$W_e = (k/r)^2 W. \qquad (1)$$

The film force is *not equal* to the effective weight, except for the rare case when the film acceleration is equal to one gravity. The film force is, however, *proportional* to the product of the effective weight and the film acceleration.

Since the effective weight varies inversely as the *square* of the radius, r,

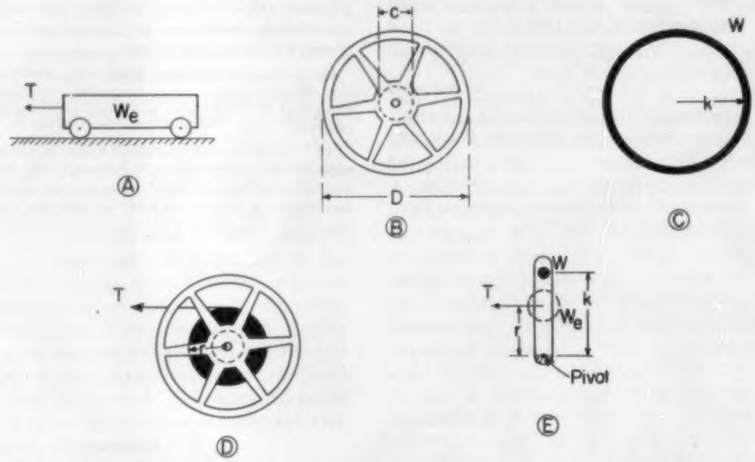

Fig. 1. Sketches illustrating the principles of effective weight and radius of gyration.

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(This paper was received on May 11, 1956.)

represented by the film already on the reel, and only as the *first power* of the weight, W, of the reel and its contained film, it would appear that the effective weight would be greatest when r is smallest, that is, when the film has just been secured to the core and $r = C/2$ (Fig. 1B). It will be shown later that this is true in all practical cases. Therefore, to obtain the effective weight, W_e, when the film is just starting to wind on the core, which is also the maximum effective weight, $C/2$ is substituted for r in Eq. (1), giving

$$W_e = (2k/C)^2 W. \qquad (2)$$

The effective weight of the empty reel, W_e, is, therefore, an important concept and furnishes a means of rating any given reel as to its relative potential for damaging film and forms the basis for determining the maximum permissible acceleration. In column 8 of Table I, the effective weight, W_e, of a number of reels is listed for sizes varying from 50- to 4000-ft capacity.

Determination of Radius of Gyration

To determine the effective weight from Eq. (2), it is necessary first to obtain the radius of gyration, k. The radius of gyration, as tabulated in column 7 of Table I, was calculated from measurements of the frequency of the reel when suspended as a pendulum on a pivot axis parallel to the spindle axis and at a known distance from the center of gravity, thus

$$k = \sqrt{c[(187.6/f)^2 - c]},* \qquad (3)$$

where k = radius of gyration about the center of gravity (normally the center of the reel), in inches; f = pendulum frequency in cycles per minute; and c = distance between pendulum pivot axis and the center of gravity, in inches.

* See Appendix A.

The greatest accuracy results if c is made small, but not too small for easy measurement.

The ratio of k/D, where D is the outside diameter of the reel, is tabulated in col. 10 of Table I. This ratio is seen to remain between the limits of about 0.34 and 0.37. This is surprisingly close to the value of 0.35, which holds for a disk of diameter D and uniform thickness and density. This value of

$$k = 0.35\ D, \text{ approximately}, \qquad (4)$$

was assumed to hold for the reels larger than 2000-ft capacity listed in Table I, because these reels were not available for measuring. Equation (4) will also be used in subsequent general equations, but it must be understood that it does not apply in cases of abnormal mass distribution in the reel.

Importance of the Core-Diameter Ratio

If the value of k given by Eq. (4) is substituted in Eq. (2), the relation is

$$W_e = 0.49W/(C/D)^2. \qquad (5)$$

The importance of a high core-diameter ratio is evident from this equation. For example, column 9 of the table shows that the ratio for reel 11 is 0.18 and column 8 shows that its effective weight is 57 lb. By increasing the ratio to 0.45, the effective weight would be lowered to about 9.1 lb! In doing so, the only penalty is a reduction in actual film capacity from 3490 to 2880 ft, or a loss of 17.5% for a better than sixfold reduction in effective weight. The original capacity can, of course, be regained by a suitable increase in outside diameter, with an attendant increase in the effective weight to about 11.8 lb or a fivefold net reduction in effective weight.

Outside Diameter of Reel

It is of importance to establish the relation between actual reel capacity in feet, the outside diameter, and the core-diameter ratio of the reel. The outside diameter establishes the space requirement at the projector, the size of shipping cases required, and is related indirectly to the weight and the effective weight.

Motion-picture film is about 0.006 in. thick, and about 15% excess capacity should be allowed for loose winding and for freeboard when the film is fully wound. Simple geometry then shows that the reel capacity in feet on the basis of these assumptions is

$$L = 9.49(D^2 - C^2), \qquad (6)$$

where C and D are in inches. Column 11 in Table I shows the capacity of the reels studied on this basis.

Equation (6) can be rearranged to read

$$L = 9.49D^2[1 - (C/D)^2] \qquad (7)$$

or

$$D = K_1 L^{1/2} \qquad (8)$$

where K_1 is a universal coefficient which is a function of C/D alone. This coefficient is plotted in Fig. 2. For an increase of the ratio C/D from 0.2 to 0.4 and a constant film capacity, the value of D increases only 6.9%. Although this is a relatively small increase, it amounts to about 1 1/8 in. for a 2-ft reel. It is very important that the dimensions of shipping containers do not become fixed at too low a value and thus limit the permissible maximum value of C/D. In particular, it is strongly advised that containers be sufficiently large to allow C/D to be at least as high as 0.5 for new large-sized reels. For a 4000-ft reel, this would mean an outside diameter of 23.7 in.

Weight of Reel as a Function of Capacity and Core-Diameter Ratio

Equations (2) and (5) for the effective weight of the empty reel contain the term W or the weight of the empty reel. This obviously changes with the size of the reel and depends upon the choice of core-diameter ratio and upon such design factors as material, flange configuration and embossings. In order to establish the trend to be expected as reels are made larger and core-diameter ratios are changed, a general equation is needed for determining reel weight based on a given design. Reels of different designs can then be compared for their effectiveness, regardless of size or core-diameter ratio. Also, the weight of nonexistent large reels can be reasonably predicted.

If all dimensions are scaled in linear relation from one reel size to another,

Table I. Characteristics of Projection Reels.

(1) Reel No.	(2) Nominal size (ft)	(3) Material	(4) Diameter: Flange D (in.)	(5) Diameter: Core C (in.)	(6) Weight W (lb)	(7) Rad. of gyration k (in.)	(8) Effect wt. at core W_e (lb)	(9) Core-diam. ratio is C/D	(10) k/D	(11) Actual capacity 15% overload allowance (ft)
1	50	Aluminum flange steel core	2 7/8	1 1/4	0.0264	0.972	0.0639	0.435	0.338	63.6
2	100	Plastic	3 11/16	1 1/4	0.0397	1.246	0.158	0.339	0.338	114.2
3	100	Aluminum flange steel core	3 11/16	1 1/4	0.0375	1.250	0.150	0.339	0.339	114.2
4	200	Steel	4 3/4	1 7/32	0.1037	1.684	0.793	0.257	0.355	200
5	400	Aluminum	7	1 1/2	0.205	2.56	2.38	0.214	0.366	443
6	1600	Steel	14 1/32	4 5/8	1.82	4.87	8.07	0.329	0.347	1668
7	2000	Steel	15	4 5/8	2.085	5.30	10.94	0.308	0.353	1930
8	3600	Sheet aluminum	19 3/8	4 7/8	2 1/8		16.40*	0.252		3340
9	3600	Wire	19 13/16	3 15/16				0.200		3530
10	4000	Wire	23	3 7/8	3 3/8		58.2*	0.169		4880
11	4000	Cast aluminum	19 1/2	3 1/2	3 3/4		57.1*	0.180		3490
12	4000	Rotating flange aluminum	22 1/4	4 7/8	3 3/8			0.219		4460
13	4000	Sheet iron	19	3 1/2	5 1/4		75.8*	0.184		3310

* Based on the assumption that $k = 0.35D$.

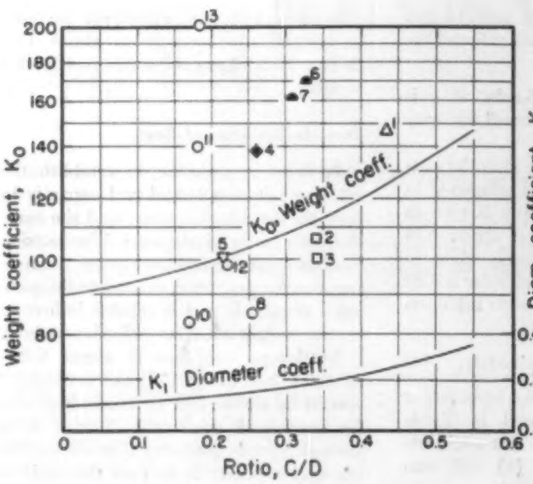

Fig. 2. Graphs giving the value of weight coefficient, K_0 and diameter coefficient, K_1, as a function of core-diameter ratio, C/D. Diameter coefficient depends only on geometry; curve for the weight coefficient is based on reel 5 and is drawn according to the considerations outlined in the text. Points are numbered according to Table I; size and material of each reel are indicated by the character of the point as follows: △ 50-ft aluminum; □ 100-ft plastic or aluminum; ◆ 200-ft steel; ▽ 400-ft aluminum; ▲ 1600-2000-ft steel; ○ 3600–4000 ft of miscellaneous materials.

the weight would vary as the cube of the diameter. However, the flange separation is not changed, and, according to theory, it is only necessary to scale the flange thickness by the two-thirds power of the diameter to maintain the same flange stiffness. The flange strength is more than adequate if the thickness is varied only by the one-half power of the diameter. Furthermore, since weight is more important in the larger sizes, it is customary in designing such reels to provide a more efficient spoke arrangement and to increase stiffness by embossing the spoke and rim members. Accordingly, it is found that existing reels vary in weight nearly according to the two and one-half power of the outside diameter or the one and one-fourth power of the footage capacity. Therefore,

$$W = K_0 L^{1.25} 10^{-6}, \qquad (9)$$

where L is the footage capacity of the reel and K_0 is a coefficient dependent upon C/D.

The value of K_0 was established with the 400-ft reel as a model and the reasoning that if the ratio C/D is changed (using the same thickness of metal), the weight of the core would increase directly as the value of C, while the weight of the flanges would vary as the square of the diameter, D. The 400-ft reel used as a model is made of 0.040-in. aluminum for both core and flanges, and has circular cutouts in the flanges, but no embossings. The value of K_0 is shown as a function of C/D by the upper curve of Fig. 2, and the equation for K_0 is derived in Appendix B. This shows the manner in which the weight changes with the ratio C/D for a fixed reel-capacity. Also plotted on this figure are points for the reels listed in Table I. Using the previous example of reel 11, it is seen that K_0 from Fig. 2 increases from 99 to 128 in changing from a C/D ratio of 0.18 to 0.45. Therefore, the weight could be expected to increase by the ratio 128/99 or from 3.75 to 4.85 lb. On the other hand, as already noted, the effective weight could be expected to drop fivefold from 57 to 11.8 lb for the same film capacity.

Equations (5) and (9) can be combined to give the effective weight of the empty reel explicitly in the form

$$W_e = 0.49 K_0 L^{1.25}\, 10^{-6}/(C/D)^2. \qquad (10)$$

This equation is plotted in Fig. 3 for common values of film capacity, L, as a function of the core-diameter ratio, C/D. These curves are plotted on the assumption that the value of K_0 follows the curve in Fig. 2. When the value of K_0 varies widely from the curve of Fig. 2, the curves of Fig. 3 will still indicate fairly well the relative effect of changing the core-diameter ratio. The significance of the broken line will be indicated later.

Effective Weight of Reel and Film

Up to this point, the discussion has considered the empty reel when the film was just starting to wind on the core. It is equally important to study the effective weight, W_r, of the reel and film when s ft of film are wound on the reel to a radius r. This case arises when the partially projected film is stopped and restarted. Since processed 16mm film weighs about 0.190 lb per 100 ft, geometrical considerations give the relation

$$W_r = 0.49\, W(D/2r)^2 + 0.0104(4r^2 - C^2/4r^2).^* \qquad (11)$$

To show the effect of added film load, it is convenient to plot the ratio of W_r/W_e as a function of the ratio of film load to rated capacity, s/L. Figure 4 is such a plot for reels of 400- and 4000-ft capacity and for the two values of $C/D = 0.2$ and 0.4. The value of s/L may vary from zero to a maximum of 1.15, at which point the film is wound flush with the reel flanges.

For the examples chosen, it is seen that the effective weight of the reel plus the film, even up to 115% of the rated capacity, is always less than that of the empty reel. This is because the contribution of the reel weight falls off very rapidly (inversely as the square) with increase of film radius. If the ratio C/D is increased to a sufficiently high value, a point is reached at which the $W_r/W_e = 1$ for the fully loaded reel. This requires a higher value of C/D for large reels than for small ones, because the reel weight relative to full-load film weight is greater for large reels. It is clear that this circumstance sets a limit to the amount by which the ratio C/D can be increased beneficially.

The broken line of Fig. 3 shows the locus of points at which the effective weight of the reel plus 115% of film-capacity load becomes equal to the effective weight of the empty reel. To the left of the broken line, the effective weight of the empty reel is greater than that of film plus reel at any usable film load. We note that the ratio C/D can be pushed as high as 0.54 for the 4000-ft reel with a beneficial reduction of W_e. *It is recommended that a value of C/D of about 0.45 be used for large reels as a good compromise between outside diameter, actual weight, and effective weight.* For this case, a 4000-ft reel would have an outside diameter of 23.0 in., could be expected to weigh 4.06 lb, and to have a maximum effective weight of 9.9 lb. This is actually one lb less than the effective weight of existing 2000-ft steel reels and, therefore, would be less damaging to the film for identical projector operation.

In the ASA Standard PH22.11-1953, there is an attempt to keep the core-diameter ratio as high as possible by making D ". . . as large as permitted by past practice in the design of projectors, containers for reels, rewinds, and similar equipment." Values of 0.4 or higher are recommended, but it was necessary to go as low as 0.308 for the 2000-ft reel. The reason stated for keeping C as large as possible is that ". . . then there is less variation throughout the projection of a roll, in the tension to which the film is subjected by the take-up mechanism, especially if a constant-torque device is used." The Standard indicates further that the take-up ten-

* See Appendix C.

sion should be kept within the desirable range of $1\frac{1}{2}$ to 5 oz. The core-diameter of the smallest reel to be used (without special provision) should, therefore, be as large as permissible. In the light of the present study, a high C/D ratio is also desirable to reduce the force on the film at starting and stopping.

It is only fair to point out that the curves of Fig. 3 are based on the assumption that the radius of gyration bears the fixed ratio of 0.35 to the outside diameter. However, as the relative core-diameter is increased, the relative core weight is also increased, and, since the core weight is always at a smaller radius than the radius of gyration for all values of C/D up to approximately 0.7, the radius of gyration relative to the outside diameter will decrease. This causes the effective weight to drop down even faster than is shown by Fig. 3. Also, designs using large core-diameters will result in an appreciable increase of flange stiffness if the attachment between core and flange is firmly made, since the spokes are shorter. Some advantage can be taken of this in reducing the weight of the flanges, thus still further reducing the effective weight.

As an indication of this advantage and of the use of embossed spokes, it was found possible to build a reel of 6000-ft capacity, using a core-diameter ratio of 0.45 resulting in an effective weight of 10 lb. The curves of Fig. 3 are conservative for the larger values of C/D. It is necessary that the design provide not only a low effective weight but also adequate strength and stiffness for all operating conditions.

Strength and Stiffness of Flanges

The laws of mechanics put a premium on making the flanges as light as possible, partly to reduce the weight of the reel and partly to reduce the radius of gyration, k. The ultimate limit is naturally set by the strength and stiffness required to withstand the vicissitudes of use and abuse.

Reels are subject to severe treatment in handling and shipping that greatly exceeds that which they receive in the normal operation of a projector or rewind. The resistance of a reel to this sort of treatment can be simulated by squeezing the flanges together at one point on the periphery and then releasing them to see whether they return to their original position. This treatment is too severe for small reels, and therefore reels of 100-ft capacity and less should probably not be called upon to meet this requirement.

Although the flanges must be able to withstand large deflections, they must, at the same time, be sufficiently stiff to limit the deflection to a very low value for the sidewise pressure which may be exerted by the film. The most severe condition of use would consist in winding a tacky film at high tension on a reel with the take-up spindle badly misaligned. If the tension is 10 oz and the coefficient of friction is 0.3, the outer convolution will push against one flange

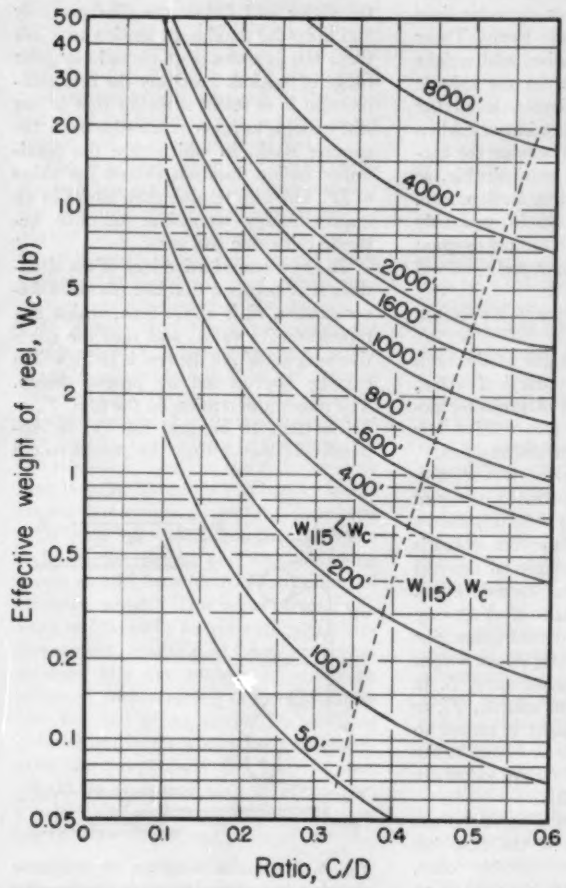

Fig. 3. Effective weight of empty 16mm projection reels on the basis of Eq. (10), with K_0 taken from the curve of Fig. 2. Broken line is locus of points for which effective weight is the same at 115% of capacity as when the reel is empty. Radius of gyration is taken as the typical constant value of 0.35 D, regardless of the C/D ratio; if reduction in radius of gyration and possible weight savings with increase of C/D ratio is taken into consideration, the curves would drop still more steeply.

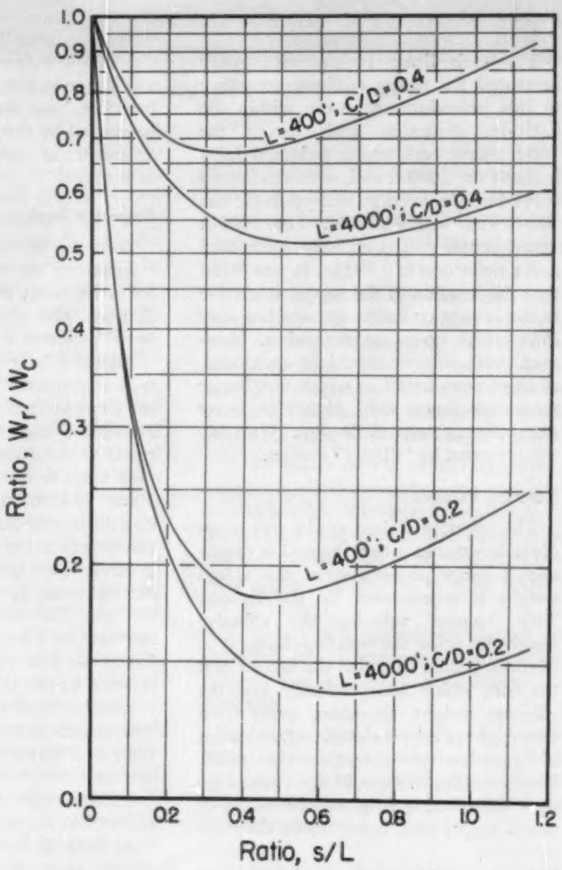

Fig. 4. Ratio of effective weight of partially filled reel to effective weight of empty reel as a function of the ratio of feet of film on the reel to capacity of the reel. Capacity of the reel and core-diameter ratio are marked on each curve.

with a total force of 1.1 lb.* This force is independent of the diameter of the film convolution, but the maximum deflection of the flange occurs when the film is wound to the maximum diameter, D. The load is distributed around the periphery of the flange. This suggests the possibility of supporting the reel as shown in Fig. 5 on supports, S. By means of a dial indicator, D, the amount of deflection at the center can be determined when the weight M is applied. The reel standard, ASA PH22.11-1953, calls for a flange separation W at the periphery of $0.660 \begin{matrix} +0.045 \\ -0.025 \end{matrix}$ in. Perhaps 0.030 in. additional plus tolerance can be taken as a deflection allowance. To standardize the test further, let us say that three supports are used, substantially equally spaced and with support shoulders which extend not more than $\frac{1}{8}$ in. in from the periphery of the reel, and that the weight, M, be 1 lb applied to an area $1\frac{1}{4}$ in. in diameter at the center of the reel. A preliminary load of $\frac{1}{2}$ lb is suggested in the form of a contact surface for the indicator and a platform for the weight. The deflection under the 1-lb test weight is to be measured from the position of the reel under this preliminary weight.

The reels listed in the table were measured for flange stiffness according to this procedure. All were within the 0.030-in. deflection limit except the 100-ft plastic reel, which deflected 0.054 in., and the 2000-ft reel, which deflected 0.043 in. The average deflection for the 400-ft reel was 0.025 in. The 6000-ft experimental reel previously mentioned had a deflection of 0.033 in. It was found that the location of the supports relative to the spokes or flange cutouts has very little effect upon the deflection. However, both flanges should be measured, as cases were found in which one flange measured almost 40% higher or lower than the average deflection. Probably this is caused by "dished" flanges.

Rotating Flanges

The effective weight of the reel is ordinarily greatest when the reel is empty and a large proportion of the actual weight is represented by the flanges. This suggests reducing the effective weight by using the rotating-flange type of construction, in which the flanges and the core rotate independently and the effective weight, therefore, arises from the weight of the core alone, whose radius of gyration is comparatively small. Theoretically, this should do much to reduce the effective weight of the empty or nearly empty reel, but it would do practically nothing for the fully loaded reel, where the weight of the film is the chief factor. This is made clear by Fig. 4, which shows that the effective weight of a well-filled reel is close to that of the ordinary empty reel when the core-diameter ratio is high, as is recommended here.

There are also mechanical complications incident to mounting the flanges rigidly on the core and at the same time permitting them to rotate freely. These complications are expensive, add weight and require more space on the spindle than is sometimes available. Even the theoretical advantages are illusory when the reel is partially filled because the friction of the film can be considerable, as was shown in the preceding section, and, therefore, the flanges would probably be carried by the film to almost as great an extent as though they were affixed to the core.

* Only the outer convolution is involved in the creation of the thrust force. The wrap angle is 2π radians. The equation for thrust force is: Thrust $= 2\pi\mu T$, where μ = coefficient of friction and T = film tension in same units as the thrust force.

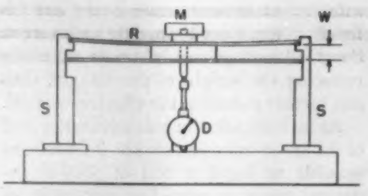

Fig. 5. Apparatus for testing the stiffness of reel flanges. R, reel under test; M, test weight; S, supports for reel; D, deflection indicator; W, separation of flanges.

Projector Design

With the effective weight of the reels reduced to the lowest practical value, let us see what features of projector design will also keep the film tension low as the projector is started and stopped.

Figure 6 is a schematic layout of a typical projector film path. In place of the conventional reels, a weight is shown attached to each end of the film which is equal to the effective weight of the reel plus film, at the time of consideration. These weights are thought of as moving on a horizontal plane without friction, like the weight in Fig. 1A. The upper weight is acted upon by a braking force, B, to the right and by the film tension, T_1, to the left. The lower weight is pulled to the right by a driving force, F, and to the left by the film tension, T_2. All forces are referred to the film radius.

Between each effective weight and the corresponding sprocket of the machine there is a spring-loaded, movable roller, SR_1 and SR_2, to absorb shock. Let us investigate the adequacy of such an arrangement for large effective weights.

As long as the projector maintains a steady state of operation with both weights moving at a uniform velocity, there is no effect produced by the weights, or $T_1 = B$ and $T_2 = F$. Suppose, however, that the projector starts from rest with very little film on the take-up reel. The effective weight represented by the lower weight is then at a maximum. Suppose further that the projector mechanism attains full speed almost instantly and that no special provision is made to increase F above the normal take-up tension of, say, 5 oz, during the starting time. For a certain time interval, all the force, F, is utilized in accelerating the effective weight, and $T_2 = 0$. At the end of this time interval, all the slack will have been taken up from the film and T_2 will start to build up, but the weight will have attained a velocity of exactly *twice* that required for steady operation. The result is an oscillating system in which the excursions of the spring roller are determined by the stiffness of the spring. If the spring is too stiff, the film will become slack when the roller moves in one direction, and will be subject to excessive tension when the roller moves in the other. Contrariwise, if the spring is too weak, the roller will follow the film properly and keep the maximum tension to a low value but at a cost of an excessively great range of motion. Probably the best compromise is to select a spring that is just stiff enough to prevent the film from becoming slack, in which case the maximum tension does not exceed the value of $2F$. The film tension then varies in an approximately sinusoidal manner between this value and zero.

To get a quantitative idea of the situation, it is assumed that the normal take-up tension, F, is about 5 oz, which is a representative value, and that the effective weight, W_e, of the reel is 10 lb, which can be approached by proper design. The maximum tension on the film, $T_2 = 2F$, is then 10 oz, and Eq. (y) in Appendix D shows that the displacement

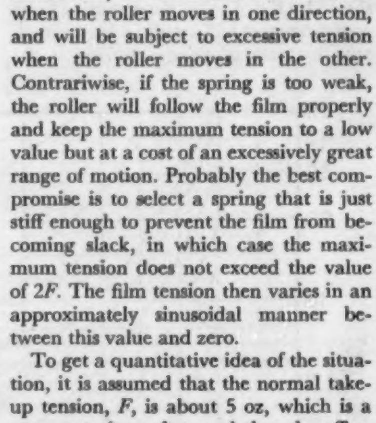

Fig. 6. Schematic diagram of projector showing use of spring-loaded rollers for controlling tension of film. W_e, effective weight of reel; B, braking force on supply reel; T_1, tension in film at supply end; F, driving force on take-up reel; T_2, tension in film at take-up end; SR_1 and SR_2, spring-loaded rollers; SS, supply sprocket wheel; TU, take-up sprocket wheel; L, projection lens; H, soundhead.

amplitude of the resulting harmonic motion is 4.3 in. If, as in Fig. 6, the film is wrapped halfway around the spring roller, the amplitude of motion of this roller is half of the value just calculated, which makes the *total* excursion of the roller 4.3 in.

The essential feature of the design is thus to select a spring that will produce 10 oz of film tension when the roller is 4.3 in. from its rest position. The period of the motion is found from Eq. (z) in Appendix D to be 3.75 sec. To cause the oscillations to disappear after a reasonably short time, some sort of damping must be applied to the roller arm.

Although this discussion has been confined to the take-up reel, exactly the same considerations apply to the supply reel. A braking force, B, as shown in Fig. 6, is required to prevent excessive slack from developing in front of the supply sprocket when the machine is stopped before all the film is run off. When the projector is started again, the same oscillating sequence is set up for the supply reel and spring roller as for the take-up reel and roller. Since both reels have the same size and the projector may be stopped and restarted near the end of the film, the need for protection is as great at the supply reel as at the take-up reel.

The situation when the projector is stopped has not been considered because the stopping of the projector is not as abrupt as the starting unless a special brake is used; in any case, spring rollers designed as described here afford protection against excessive film tension.

It is true that many projectors are equipped with at least one spring roller or its equivalent, but they are usually designed for reels of comparatively small effective weight. For reels of large effective weight, the stiffness of the spring or the allowable travel of the roller or both may require alteration. When it is expected that a given projector will be used with reels of widely varying effective weights, the spring and the allowable travel should be selected for the largest effective weight. This arrangement will work satisfactorily for reels of lower effective weight, resulting in lower peak film-tensions but not as low as could be achieved with a spring of lower stiffness (see Eq. (w) of Appendix D), and, as pointed out in the preceding paragraph, both the supply and the take-up ends should be equipped with spring rollers. Figure 7 shows an experimental setup using the 6000-ft test reel.

Fig. 7. Experimental setup using 6000-ft test reel.

Other Design Considerations

It goes without saying that the use of any proposed large reel size requires that the supporting arm, the spindle bearing, the reel-attachment means, and the take-up torque or supply brake capacity be adequate for the greater weight and diameter involved. The $\frac{5}{16}$-in. standard spindle is a weak point, but perhaps it can be used largely for centering, with the major alignment and torque burden being carried by a flange member of, say 3-in. minimum diameter on the spindle. Perhaps not all existing spindles can be made to support 4000-ft or larger reels, but it seems possible that a spindle design can be worked out which will function adequately with such large reels and with the smaller standard reels.

Supplying the greater torque needed for the larger reels and the range of torque involved for the interchangeable use of large and small reels is a problem, but it is by no means insurmountable. Even ultralarge reels seem within the realm of possibility, but might require servosystems of torque control. Take-up drives using slipping clutches, slipping belts, or direct-connected electric motors may require increases in size or a change in speed ratio for larger reels. However, the actual power used by the take-up reel is not greater for larger reels than for small ones. If a large range of core sizes is to be accommodated by a single take-up drive, some means (preferably automatic) of speed change or torque conversion is needed. In any event, a controlled, variable torque output is required.

Conclusions

This study is not the final work on the subject; additional experimental reels should be made and tried on a projector and further investigation will be needed to understand completely the nature of cinching and the requirements to avoid cinching. However, the following conclusions appear to be warranted at this time:

1. The effective weight and the consequent potential film damage resulting from starting and stopping the projector can be greatly reduced by using a large core. It is recommended that the core be at least 45% as large as the outside diameter of the flanges, for the larger reels.

2. By following the preceding recommendations and average design and construction with light-weight materials, it is expected that 4000-ft and larger reels can be constructed with less effective weight than the 2000-ft reels in present use.

3. Simple test procedures can be established for determining whether the stiffness and strength of reel flanges are adequate.

4. Comparatively simple spring shock-absorbers with suitable damping built into projectors or as auxiliary equipment will enable large reels to be used without damaging the film.

Standardization Proposals

These conclusions indicate that certain recommendations in the ASA standards should be revised, namely:

1. The ASA Standard PH22.11-1953, 16mm Motion-Picture Projection Reels, should contain the recommendation that all new reel sizes, particularly those above 2000-ft capacity, be designed with the core diameter not less than 45% of the outside diameter.

2. Standards of stiffness and strength for the flanges along the lines outlined in this paper should also be included.

3. If projectors are to meet the requirements of repeated projection of the same film with adequate film life for any reel size, the standards and recommended practices should be written to include the effects of starting and stopping, particularly when large reels are involved. Perhaps this can be done with comparatively simple changes in the existing standards. For example, in ASA Standard PH22.91-1955, 16mm Motion-Picture Projectors for Use With Monochrome Television Film Chains Operating on Full-storage Basis (published, *Jour. SMPTE, 64:* 203 Apr. 1955), the following changes might be made:

A. Change 12.2 to require that a 10-oz force be introduced into the section of the film loop between the take-up sprocket and the supply sprocket. This could be done by means of a floating roller to which a 20-oz weight or spring load is attached with suitable idler rollers to give the normal entering and leaving film directions at the sprockets. The purpose of this addition is to insure that the sprockets with associated keepers, rollers, etc., are able to sustain a 10-oz film load without objectionable damage to the film in 100 passes. Perhaps the splice (of good quality) should not be excluded from the test, but be required to take at least 50 passes.

B. Include in 11.2 the statement that this also applies to starting and stopping with the largest reel for which the projector is to be operated as well as to steady running conditions. Such a test could be very conveniently conducted on any projector equipped with spring rollers, as indicated in Fig. 6, provided the rollers are free to move far enough. The test would consist in first noting under static conditions the spring-arm position which corresponds to 10-oz of film tension and then noting whether this position is exceeded at any time during operation. Special note should be made when the projector is started with nearly empty reels on both the supply and the take-up spindles.

It may be possible that further investigation will prove that the 10-oz upper limit mentioned in 11.2 and proposed in 12.2 can be raised if the essential results of 100 passes without objectionable film damage can be achieved under all conditions of normal operations, including repeated starts and stops with the largest reels at the same section of film. It may also be possible that further studies on cinching may impose additional requirements, such as the minimum take-up tension existing longer than a specified fraction of one reel revolution in relation to the permissible maximum tension.

APPENDIX A

Calculation of Radius of Gyration

The radius of gyration, k, of a physical pendulum about its center of gravity can be determined if the pendulum natural frequency, f, in cycles per minute is known for low amplitudes of swing about a pivot axis at a known distance, c, from the center of gravity.

Assume that the center of gravity of the pendulum is displaced from a point directly under the horizontal pivot axis such that the line joining the center of gravity and the point on the pivot in a plane perpendicular to that axis makes the small angle θ with the vertical. The component of gravity pull, W, which is normal to the line joining the center of gravity and the pivot axis, is

$$W \sin \theta. \qquad \text{(a)}$$

This gives rise to a torque, T, tending to return the pendulum to its neutral position, where

$$T = cW \sin \theta, \qquad \text{(b)}$$

or for small values of θ, the equation can be written

$$T = cW\theta, \qquad \text{(c)}$$

where θ is measured in radians. This is the condition for free, simple harmonic rotational oscillation with torque T proportional to the angular displacement from a neutral position, being exerted on a mass whose moment of inertia about the pivot axis is

$$I = \frac{W}{g}(k^2 + c^2), \qquad \text{(d)}$$

where W is the pendulum (or reel) weight, and g is the acceleration of gravity (= 386 in./sec.^{2}).

The torque constant for the system is

$$\frac{T}{\theta} = cW. \qquad \text{(e)}$$

The well-known equation for natural frequency then gives

$$\omega = \sqrt{T/\theta I}, \qquad \text{(f)}$$

where ω is the natural frequency in radians per second. By substitution from (d) and (e), the relation is

$$\omega = \sqrt{cg/(k^2 + c^2)} \qquad \text{(g)}$$

or

$$k = \sqrt{c(g/\omega^2 - c)}. \qquad \text{(h)}$$

If g is replaced by its numerical value, and ω is replaced by its equivalent, $(\pi/30)f$, the result is

$$k = \sqrt{c[187.6/f)^2 - c]}. \qquad \text{(i)}$$

APPENDIX B

Equation for Weight Coefficient K_0

The weight coefficient expresses the manner in which the weight of a reel changes as the core-diameter ratio C/D is changed but the footage capacity, L, is kept the same.

The 400-ft reel made of 0.040-in. aluminum was used as a model. By calculation, it was found that the core weight is 0.013 lb, while the remaining flange weight is 0.192 lb. If the outside diameter, D, is increased by changing all dimensions of the flanges proportionally except that the thickness is kept constant, the flange weight will vary as the square of D. If the core diameter, C, is changed, the core weight will vary directly as C for constant material thickness; therefore,

$$W = 0.192(D/7)^2 + 0.013(C/1.5), \qquad \text{(j)}$$

for a reel whose actual capacity is 443 ft, calculated according to the equation, $L = 9.49\ D^2[1 - (C/D)^2]$, as given in the text, or

$$D^2 = \frac{L}{9.49[1 - (C/D)^2]}. \qquad \text{(k)}$$

By substitution of (k) in (j), the equation for the 443-ft capacity becomes

$$W = \frac{0.183}{1 - (C/D)^2} + \frac{0.059\ C/D}{\sqrt{1 - (C/D)^2}}. \qquad \text{(l)}$$

But also,

$$W = K_0 L^{1.25}\, 10^{-6} = 2030 K_0 10^{-6}. \qquad \text{(m)}$$

Therefore,

$$K_0 = \frac{90.2}{1 - (C/D)^2} + \frac{29\ C/D}{\sqrt{1 - (C/D)^2}}. \qquad \text{(n)}$$

APPENDIX C

Effective Weight of Reel and Film

When film is wound on the reel to radius r, the contribution of the weight of the reel, W, to the total effective weight is

$$W_r\ \text{(reel)} = 0.49W(D/2r)^2, \qquad \text{(o)}$$

as might be expected from the discussion in the text based on the radius of gyration of the reel = $0.35D$.

For film weighing 0.190 lb/per 100 ft, the weight per square inch of edge area is 0.0264 lb for 0.006-in. thickness. Since the effective weight is equal to the actual weight times the square of the ratio of radius of gyration to the reference radius and, since, for a homogeneous disk, the radius of gyration equals 0.707 times the disk radius, the value for the film is

$$\begin{aligned} W_r\ \text{(film)} &= 0.0264\,\pi[r^2(0.5) - (C^2/4)(0.5)(C/2r)^2] \\ &= 0.0104\,(4r^2 - C^4/4r^2). \qquad \text{(p)} \end{aligned}$$

The addition of Eq. (o) to (p) gives the required total result for W_r.

APPENDIX D

Spring-Roller Calculations

The equations for film tension, displacement amplitude, and period are most easily derived if the case of the take-up reel is considered starting from rest, but assuming that the drive force, F, is already applied and that this is balanced by the film tension, T, so that the spring roller is already in its midposition of travel at the instant of starting. The starting time of the projector is considered to be short compared to one period of oscillation, so that a short time after the switch is thrown, film is being delivered to the spring roll at the constant linear velocity, $V = 7.2$ in./sec, for 16mm sound film.

This establishes the conditions for sinusoidal oscillation right from the start, with the velocity varying from zero to 2 V until such time as the oscillations are damped down or unless conditions call for a greater maximum acceleration force than F, for which case film slack will develop and intervals of time for which constant acceleration equations apply will be interspersed between intervals of sinusoidal motion.

Let p be the net force available for accelerating the reel, where

$$p = F - T. \tag{q}$$

The driving force, F, is a constant determined by the take-up torque and the film radius.* As the film tension, T, decreases, the value of p increases, and p cannot exceed a maximum positive value of F, since T cannot become negative. The value of p is negative (i.e., the reel is being slowed down) if T is greater than F.

Let A be the amplitude of the sinusoidal component of the film displacement. This is manifested in the shift of the spring roller from its midposition of balance, and, if the film wrap is 180° on the spring roller, the roller shift is just one half of A. It is known from sinusoidal considerations that the amplitude of the acceleration equals $A\omega^2$ where ω is the natural frequency of the spring and the effective weight in radians per second. Therefore, since force equals mass times acceleration,

$$P = \frac{W_r}{g} A\omega^2, \tag{r}$$

where P equals the amplitude or maximum positive and negative value of p, W_r is the effective weight ($= W_e$ for an empty reel), and g is the acceleration of gravity ($= 386$ in./sec.^{2}).

It is also known from the sinusoidal relationship that the amplitude of the velocity equals $A\omega$. This amplitude is known to be equal to the steady-state velocity, V, as just stated. Therefore,

$$A = \frac{V}{\omega} \tag{s}$$

and

$$P = \frac{W_r}{g} V\omega. \tag{t}$$

As the natural frequency, ω, is reduced (by reducing the spring stiffness for a given W_r), the force, P, is also reduced. However, the amplitude, A, and the roller excursion are increased by reducing ω. The effective spring constant, K, is equal to the ratio, P/A. For 180° film wrap, the actual spring constant is $4K$, as measured at the center of the roller. By means of this relation, Eqs. (s) and (t) can be solved for ω, resulting in the well-known resonance frequency equation,

$$\omega = \sqrt{Kg/W_r}. \tag{u}$$

Substitution of Eq. (u) in (s) and (t) gives

$$A = V\sqrt{W_r/Kg} \tag{v}$$

and

$$P = V\sqrt{K\,W_r/g}. \tag{w}$$

The force, P, should not exceed F, for if it does, the film tension will drop to zero and slack will develop for a brief interval during each cycle. Also, the maximum tension will exceed 2 F and this may be undesirably large. For the compromise case of $P = F$, it is found that

$$K = \frac{F^2 g}{V^2 W_r} = 7.45\,\frac{F^2}{W_r} \text{ for } V = 7.2 \tag{x}$$

and

$$A = V^2 W_r/Fg = 0.134\ W_r/F \text{ for } V = 7.2. \tag{y}$$

For the example of $W_r = 10$ lb and $F = 0.3125$ lb (5 oz), $K = 0.0726$ lb/in. and $A = 4.30$ in.

The period Q or time for one complete cycle equals $2\pi/\omega$ or

$$Q = 2\pi\sqrt{W_r/Kg} = 0.320\sqrt{W_r/K} \tag{z}$$

For the example here, $Q = 3.75$ sec.

Equations (v) and (w) indicate that if the spring constant is not changed but a reel of lower effective weight is used, both the amplitude of oscillation and the maximum film tension are reduced by the square-root relation.

If the film tension is zero but there is no slack at the instant of starting the projector, it is found that, upon removal of the slack which develops, the film velocity at the reel has reached 2 V and later when the spring arm reaches its mid-balance position, the film velocity is still greater. The solution to this case indicates that both A and P are increased by the ratio $\sqrt{2}:1$ for the example presented. The period remains substantially constant, but short intervals of zero film-tension will exist until the amplitude is damped sufficiently. If some slack exists at the time of starting, the situation becomes worse. Therefore, it is desirable that favorable starting conditions prevail, and some marginal spring-roller travel must be allowed for unfavorable conditions.

* For some types of drive, this is not the case. Constant-torque drives would generally supply constant F during starting, but would be modified by "break-away" torque and maximum available speed.

Stainless-Steel Bearings for Film-Processing Machines

By LEONARD F. GIARRAPUTO

Bearings for high-speed motion-picture film-processing machines have always presented unique engineering problems. These problems became more serious and more difficult to overcome upon the introduction of color films because of the higher corrosive properties of certain color film processing solutions. Extended tests on a variety of bearing types led to the development of a two-piece, deep-groove ball bearing with a No. 316 (18-8) stainless-steel retainer that has low-friction and excellent life characteristics when operated in either black-and-white or color film processing solutions.

Pathé Laboratories, Inc. was one of the pioneers in the application of antifriction bearings for high-speed processing equipment for motion-picture films. Upon the introduction of color films for laboratory processing it was apparent that bearings which had proved practical for black-and-white processing equipment would probably not meet the requirements imposed by the high corrosive properties of color film bleach solutions, and possibly other solutions would cause trouble.

An investigation was undertaken to solve this particular problem, but at the same time it was hoped that other desirable features could be incorporated in a newly designed bearing that would have improved overall characteristics for motion-picture processing machines. This investigation was directed toward answering three principal questions:

(1) What type of bearing is most suitable for the purpose, i.e., a sleeve or antifriction type?

(2) What materials or combination of materials will give longest life?

(3) What set of compromises represents the best general solution, considering initial and replacement costs, running properties, frequency of replacement, and routine maintenance costs?

Previous Experience

For black-and-white film processing machines, Pathé and most other laboratories had adopted stainless steel (No. 440) ball bearings for solution tank rollers after many years of testing a variety of materials and bearing types. These proved so practical that the bearing problem became almost a forgotten issue until the introduction of color films. Partly because of lack of experience but mostly because of necessity, the same bearings as used in black-and-white machines were employed in earlier color film processing machines. The study of bearings previously mentioned was greatly intensified when experience showed the No. 440 stainless steel ball bearing to be unsatisfactory. These bearings corroded rapidly, requiring frequent checks and replacements which naturally caused a loss in plant operating efficiency, increased costs and excessive film spoilage.

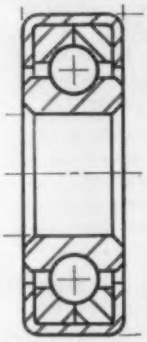

Fig. 1. Cross section of No. 302 stainless-steel ball bearings.

It was learned that other laboratories were experiencing similar difficulties, and that bearing tests conducted prior to the introduction of color materials were being re-evaluated. In addition, tests were being conducted on more recently developed materials, e.g., sleeve bearings made of Nylon, Renox and other synthetic plastics. Such bearings functioned well from a wear standpoint, but friction drag of the guide spools in which the sleeves were inserted increased markedly. This caused film scuffing and film breakage. The friction drag could be compensated for to some extent by additional power drives, thus minimizing scuffing and breakage difficulties. However, the cost of synchroizing the multiple drives was high. Two manufacturers introduced No. 302 stainless-steel ball bearings of three-piece construction, that is, a one-piece inner ring and a two-piece outer ring, held together by a steel band. The bearing had a full complement of balls.

Figure 1 shows a cross-section drawing of the construction. It was found that, while these bearings were suitable for mild acid solutions at low speeds and light load application, there was a tendency for the outer race to separate. This appeared to be due to salt crystals which were ground into the parting edge of the two-piece outer race by the rotation of the balls. This action eventually loaded the parting edge so much that separation occurred. It was also found that the axial play in the three piece bearings varied greatly. One could never be sure that spool assemblies would not travel sideways and cause trouble. Another undesirable characteristic of the bearing produced a heating action and smearing of the balls. This may have been caused by the fact that the bearing has a full complement of balls and, during rotation, as the balls emerge from the unloaded to the loaded portion of the bearing, they rub against one another and produce the heating and resultant smearing. The effect grew progressively worse during operation of the bearings in locations where crystal formation was not a problem. Thus, this type of bearing, even if made from suitable material, is not satisfactory.

Outcome of Recent Tests

Several manufacturers offered their

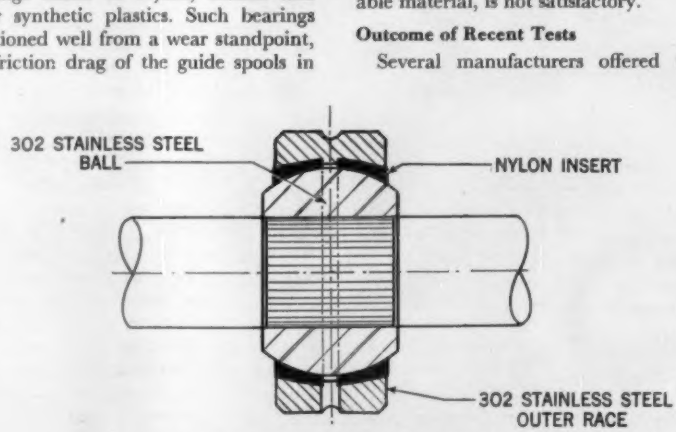

Fig. 2. Ball-and-socket sleeve bearing.

Presented on April 30, 1956, at the Society's Convention at New York by Leonard F. Giarraputo, Engineering Dept., Pathé Laboratories, Inc., 105 E. 106 St., New York 29.
(This paper was received on April 6, 1956.)

Figure 3

various types of bearing for tests. (There was always the likelihood that a standard bearing could meet requirements.) A ball-and-socket sleeve bearing, as shown schematically in Fig. 2, was tried and rejected. This bearing consists of a No. 302 (18-8) stainless-steel bored ball and outer member, with a Nylon insert. As shown by the drawing, the Nylon contacts approximately 60% of the ball surface. The self-aligning ability of this bearing is an advantage, but the friction is as high as in a properly fitted Nylon sleeve bearing of ordinary type. Also, the initial cost of the bearing is high and requires further expense for reworking existing rollers.

Next, a ball bearing made with a No. 302 (18-8) stainless-steel raceway and Nylon balls was tried. At first this bearing appeared to be suitable but under actual operating conditions the length of service proved to be greatly inadequate. The reasons for this unexpected poor life characteristic were not explored thoroughly, but cursory inspections at different stages of use indicated that the small swelling of the Nylon balls was sufficient to fill the normal clearance between the raceway and ball surface, thus accelerating their wear.

The manufacturer of this bearing supplied samples with alternate balls of Nylon and No. 302 stainless steel. This alteration improved the service life somewhat but not enough to allow acceptance of the bearing for production application.

Following further fruitless trials along conventional lines, it was finally decided to approach the problem from other directions. Consultations with a leading bearing specialist were held and, as one would expect, an austenitic structured stainless steel (No. 316 18-8) was recommended because of its exceptionally high abrasion and corrosion resistance. The difficulty in working this material, which caused it to be eliminated in previous considerations, presented the problem of locating a bearing manufacturer experienced in, and willing to work with, No. 316 stainless steel in small lot runs. The major manufacturers were not inclined to cooperate, especially since a sample run of a newly designed and yet unproved bearing was involved. Fortunately, one manufacturer was persuaded by our consultant to produce a sample lot as a tool room job.

From past experience it was felt that the new bearing should have the largest practical ball size, with one-piece inner and outer raceways to eliminate possible wear points found in split outer race type ball bearings. For the sample run, the manufacturer adopted a ball cage of standard type as shown in Fig. 3 and made the retainers with existing dies, of No. 316 stainless steel. The balls were made of this same material. The preliminary test installation on a high-speed processing machine to evaluate the service life of this metal was made in February 1952. The results were very favorable, although some desirable design changes were immediately apparent. The ball retainer pockets proved too large. The retainer dropped below the pitch line of the balls and dragged on the land of the inner race, resulting in undesirable friction. The manufacturer agreed to use still larger balls, i.e., $\frac{9}{32}$-in. instead of $\frac{1}{4}$-in. balls, fitted into deeper grooves. Bearings of this type with $\frac{1}{2}$-in. and $\frac{5}{8}$-in. bore were produced for tests.

The larger-ball, ball bearing proved to be far superior to that with a smaller ball. But after a few months of operation, chemical salts formed crystals in the ball pockets, which produced sticking. It was evident that the cage surrounded the balls too closely and that a new design was necessary. This further demand upon the manufacturer was refused because of the small quantities needed for tests and the high probability that large runs of such a special-purpose bearing could never be realized.

Our bearing specialist at this point took over the manufacturing details privately. The new design entailed closer tolerances, a finer finish for the ball track, and a completely new, open-type retainer which would flush itself free of chemical crystals during operation. No. 316 stainless steel was employed throughout to prevent the electrolytic action encountered with dissimilar metals. The slight increase in cost imposed by this specification is outweighed by the superior performance of a properly made bearing.

A cross-section view of this new bearing is shown in Fig. 4. Note particularly the deep grooves and the open-type cage. Experience so far is very convincing in favor of a two-piece, deep-groove ball bearing made entirely of No. 316 (18-8) stainless steel for either black-and-white or color film processing equipment. Of all the bearings tested at this source, this new type has the following advantages:

Fig. 4. Cross-section of new bearing.

(1) Highest antifriction characteristics;

(2) Reduced starting torque (achieved by use of large balls);

(3) No damage to raceways from salt formation (due to deep-groove one-piece raceways);

(4) No crystal formation in ball pockets (prevented by open-type retainer); and

(5) Superior resistance to corrosion (due to use of No. 316 stainless steel throughout).

Only one caution seems appropriate for the unitiated. No. 316 stainless steel is "soft" in comparison to No. 440 stainless steel or chrome steel, and so its load and shock carrying capacity are necessarily less. However, if this is kept in mind, ball bearings made of No. 316 stainless steel will give longer life and smoother running equipment than bearings made of any other type of material. The processing machines at Pathé Laboratories are running faster than ever, and with less maintenance and down time than in any previous year.

Acknowledgment

We wish to acknowledge the technical assistance and aid given to us by Dalc Bearings, Inc., 1917 Broadway, New York, N.Y.

Discussion

Carl F. Turvey (U.S. Dept. of Agriculture): Could you give the approximate price per bearing?

Mr. Giarraputo: We buy them in thousand lots, and they come to about $2.00 a bearing; but I imagine if you ordered less the price naturally would be more. I understand from the manufacturer that they are going to keep a complete stock of bearings in New York and you will be able to order one or one hundred.

Albert A. Duryea, Chairman (Consolidated Film Labs.): The problems of getting a bearing to stand up on a processing machine that runs in the neighborhood of 250 or 300 ft/min are quite different from the bearing problems on a machine that runs say under 100 ft/min. I've seen these bearings perform and they certainly have good wearing properties and they have a lot of desirable features. They're very smooth running compared with the old type of stainless steel ball-bearing that didn't have any retainer. A ball bearing without a retainer has a tendency to have the balls cram and excessive wear results and the first thing you know you have an egg-shaped bearing.

Plastics in a Motion-Picture Processing Machine

By JOHN W. RAYMOND

Many plastics provide excellent chemical resistance and ease of fabrication. Their flexibility, low joint strength and heat distortion require special consideration in machine design. Utilizing hot impinged air drying and compactness, AirLab has built a 16mm, black-and-white, negative-positive machine using Uscolite, Epon, Tygon, Nylon and Neoprene to make racks, piping, elevators, special valves, sheaves and tank linings simply and at low cost. Results indicate the suitability of some of these materials in a color machine.

In considering the construction of a motion-picture processing machine, there were established several performance and construction requisites which led to the use of plastics.

First, the machine must be as compact as possible yet provide the highest possible output with normal temperatures. At the same time it must provide the degree of precision control necessary for first-class commercial work along with reproducibility of results. Second, it must be built at a low initial cost, require a minimum investment in jigs and tools, be simple to maintain, operate at a cost low enough to permit comparatively small volume, intermittent operations and be adaptable to any type of process.

Although this paper deals primarily with the use of plastics in accomplishing these ends, the largest contributing factor making their use feasible was the incorporation of hot impinged air drying. The drybox so constructed measures 36 in. high, 5 in. thick, and 20 in. wide. This design not only eliminated from consideration the structural requirements of a conventional drybox but also simplified the drive and structure of the wet end.

Credit for the development of impingement drying goes to F. Dana Miller and the Manufacturing Experiments Div. of the Eastman Kodak Co. A very detailed paper in the *Journal*[2] provided the basis for the design incorporated in the machine.

The number of types of plastics available for photographic equipment is quite large. An article published in 1953[3] provided the basis for the materials used. Muehler and Crabtree listed in that article the photographic and equipment suitability of twenty-one types of plastics. Nine points were used for considering the chemical and photographic suitability and seven points for equipment suitability. With the exception of a few types under specific conditions of use and some reservations on others all of the materials listed were generally recommended. As for equipment suitability in some instances no data were available or recommendations were given with reservations or the plastic was not recommended. The equipment suitability recommendations were made upon a consideration of physical properties, availability of material in certain forms, practical fabrication difficulties, and other points affecting the advisability of utilizing the material for a given type of equipment: for example, ease of breakage and difficulty of repair.

The physical properties of most plastics have limited their use in the laboratory except for small parts. As a general rule it is not feasible, and in some cases it is impossible, to make a direct substitution of plastics for stainless steel in a machine of conventional design. The flexibility, low-impact strength, low heat distortion point and low joint strength require special consideration. It was determined that by reducing all parts to their simplest form and using the techniques of aircraft designers who make light weight materials into strong assemblies, plastics could be used for fairly large structures as well as small parts.

The first results of this effort are shown in Fig. 1. This is the complete machine and related storage tanks as seen from the feed-in end. From the feed-in elevator to the take-up elevator it is 54 in. long, 20 in. wide and 48 in. high. With the storage tanks it occupies 36 sq ft of floor space. Within the 54-in. length are a feed-in elevator, developer tank and associated weir tank, an acid rinse tank, a fixative tank and associated weir tank, a wash tank, a combined Photo-Flo tank and air squeegee, the drybox and the take-up elevator. An accessory section at the take-up end adds another 21 in. to the total length and contains the drive motor, drybox blower, the ducts and heaters, the squeegee blower and all electrical controls. It can readily be seen in this view how much the impingement drybox contributes to the reduction in size and simplicity of the whole structure, leaving the major portion of the machine devoted to the wet end.

Plastics have been used in the machine in the following manner. Although the frame is a standard extruded aluminum angle it has been treated with a mild acid primer called Tygorust and then coated with Tygon paint. This material is a polyvinylchloride made by the United States Stoneware Co.

For experimental purposes both ma-

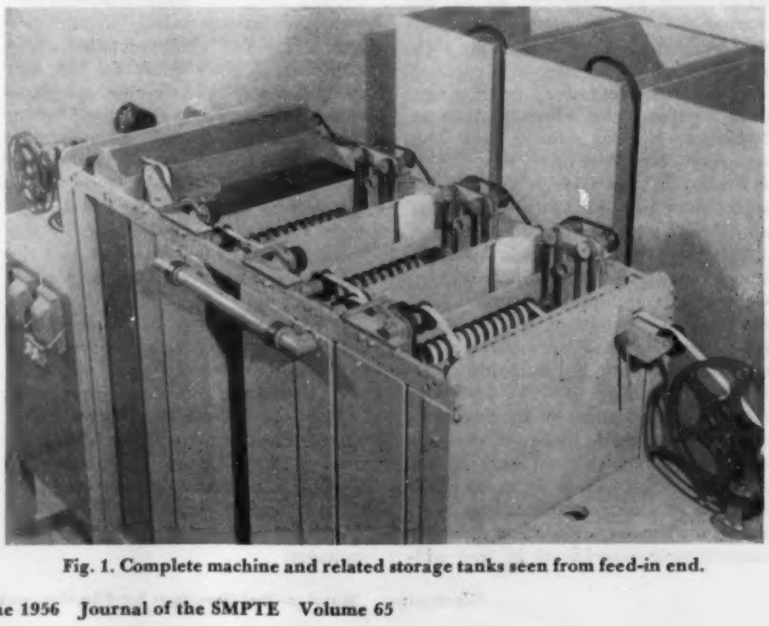

Fig. 1. Complete machine and related storage tanks seen from feed-in end.

Presented on April 30, 1956, at the Society's Convention at New York, by John W. Raymond, AirLab, 2405 Airline Way, Phoenix, Ariz.
(This paper was received on April 5, 1956.)

Fig. 2. Circulation system made of Uscolite.

Fig. 3. Reverse view of circulation system.

chine and storage tanks are made of plywood, glued and screwed together then primed and finished with five coats of Tygon paint. Tygon is satistory for black-and-white processing chemicals but is not recommended for color developers. Tanks made in this manner have been estimated to last only a year. In the final machine for actual laboratory operation they will be replaced by either a Fiberglas or Uscolite tank of slightly different design.

The three combined storage and circulation tanks behind the machine are for negative and positive developers and the third is for fixative. They hold 60 gal each. A floating lid made completely of Uscolite plastic keeps them virtually sealed during all operations and provides one of the means of keeping the operating costs down.

In making the selections of the materials to be used, all factors were considered. Some of the plastics investigated had all the desirable characteristics, both chemical and physical, but their cost was almost equal to stainless steel. One authority expressed the opinion that if it cost that much you might as well use stainless steel and gain structural strength. The plastic selected for the majority of parts in this machine is a styrene-acrylo-nitrile-butadiene copolymer manufactured by U.S. Rubber Co. under the trade name of Uscolite, type CP.

Muelher and Crabtree recommended the material on all nine points for chemical and photographic suitability. These include: (1) a moderate alkalinity developer, (2) caustic developer, (3) mild acid rinse or stop bath, (4) aluminum hardening fixing bath, (5) aluminum hardening rapid fixing bath, (6) chromium hardening fixing bath, (7) bichromate bleach for black-and-white reversal processing, (8) ferricyanide bleach and (9) washing. Since the article was published tests have been made by several concerns and this plastic has been found suitable for some color developers.

Also in selecting this product it seemed to fit most of the physical requisites which we had established at the outset: (1) although it is quite abrasive it can be machined readily and accurately with conventional machine tools; (2) it can also be easily worked with wood or metal hand tools; (3) it is solvent welded with methyl ethyl ketone although a special methyl ethyl ketone base cement is supplied; (4) it is available in sheet, slab, bar, standard wall pipe, extra heavy wall pipe and pipe fittings of the standard design and valves; (5) the pipe is quite rigid in lengths up to 4 ft; (6) it has good dimensional stability, particularly in the heavier sections, the heat distortion point being 170 F; (7) at least one surface is very smooth; and (8) it sells for several times less than the equivalent size of stainless steel. In spite of the above list of advantages there are some problems connected with this material. These will be discussed later.

Figure 2 shows how Uscolite has been used to fabricate the complete circulation system. The distance between the storage tanks and the machine is 36 in. Here extra heavy wall pipe has been used as tubing and has been solvent welded with a butt joint. The fit into the valves is a pipe-threaded joint. The aircraft stainless steel hose clamp couplings were used as a simple, inexpensive means of joining the sections. They have proven quite satisfactory. They do not leak or damage the pipe. In the future grooved pipe ends and Victaulic couplings will be used because they provide a stronger joint.

In using solvent welded butt joints we encountered the first limitation of the material. This method means that the weld is absorbing directly any flexing loads. It does not require very much flexing before the weld shows strain by turning white and failing soon after. It is important therefore to support the pipe adequately at both ends and in this case in between with a simple stand-off from the floor which is also made of Uscolite.

After much experience with this material and trying different techniques we have finally evolved a type of solvent weld joint which relieves the weld of a direct strain. A special tool is required to form the pipe ends to be cemented.

In the case of threaded pipe, care must be taken during assembly not to force the threads without adequate lubrication or they will be next to impossible to take apart. Threaded joints will withstand more flexing without breaking but may be distorted enough to leak slightly. Primarily the requirement for quick cleaning has resulted in our seeking a more desirable type of joint for both the permanent as well as the break-apart variety. This must not give the idea that either solvent welded or threaded joints are always on the verge of failure, for, on the contrary, they are very strong and reliable; but an extra margin of safety against darkroom accidents or wrestling with stuck valves was wanted.

The black valves on the right (Fig. 2) are a hard rubber plug cock. A Hills-McCanna valve with an Uscolite body and Neoprene seal is now available and will replace these. On the left side of the picture, tucked under the frame of the machine is a Buna-N rubber pump. This is manufactured by Gorman-Rupp. They feed directly into the bottom of the tanks and one leg of the film rack.

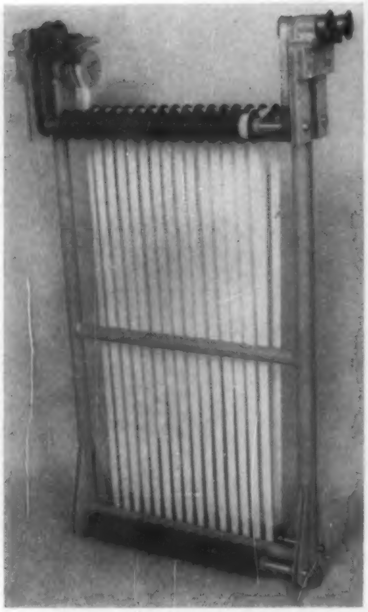

Fig. 4. Typical film rack.

For color developers and bleaches a pump body of Uscolite will be used. The shafts are sealed with a rotating carbon ring against stainless steel.

Figure 3 is a view, reversed in relation to Fig. 2, of the circulating system and features the tree valve which is all plastic, even to the threaded shafts. These valves have a Neoprene seal to assure complete closure. They operate either completely closed or open and permit complete draining of the entire system of residual chemicals. In the upper left the common developer system is seen. Below that is the fixative system. Next to the machine is the water system. The riser duct of the dry box is on the right.

Figure 4 shows a typical film rack. Except for the stainless steel shafts it is made completely of the same material. Solution from the pump enters the riser on the right and is distributed through the three cross members and sprayed against the film through small holes. All wet-end racks are the same and are interchangeable.

Because of the strains of both the drive system and film travel combined with the pressure of the solutions from within the rack it is necessary to support the rack at the top with two bolts and at the bottom of the tank with a slip-over coupling attached to the bottom of the tank.

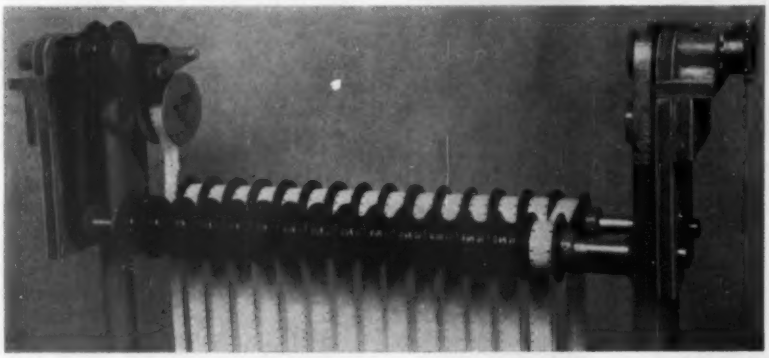

Fig. 5. Detail of rack drive.

It is interesting to note an additional advantage accruing from the compact design. There are no elevators, clutches or over- or under-drives required. Only the top shafts drive. This rack contains 166 ft of film.

Figure 5 shows a little more detail of the rack drive. The rollers are Durez and have Uscolite centers. You will also note that the steel shafts ride directly in the Uscolite as do the bottom rollers. All indications are that as long as they are lubricated by the solution that this type of bearing will have excellent life considering that the maximum shaft speed is only 400 rpm. The thrust collars are also of the same material and are attached with stainless set screws.

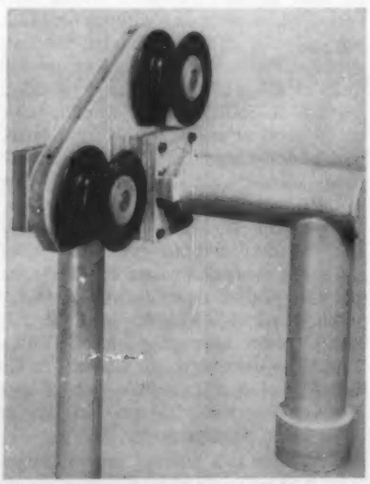

Fig. 6. Air squeegee and portion of Photo-Flo rack.

Figure 5 also shows the driving method for the shafts. A Neoprene-nylon timing belt manufactured by U.S. Rubber is used. These belts have stranded wire imbedded in them for longitudinal strength. The sheaves are made of another type of plastic. A resilient vinyl mold was made from a steel master. An epoxy casting resin manufactured by the Shell Chemical Corp. and known as Epon 828, when combined with the appropriate catalyst and a filler of powdered silica and baked, produces a smooth, precision sheave. The resin is inert and although it has a low impact strength is very suitable for this use.

Figure 6 shows the air squeegee and a portion of the Photo-Flo rack. Here again only the roller shafts, squeegee rollers and set screws are stainless steel. The squeegee is a modified form of the Capstaff air knife in that the nozzles direct the air blast downward.

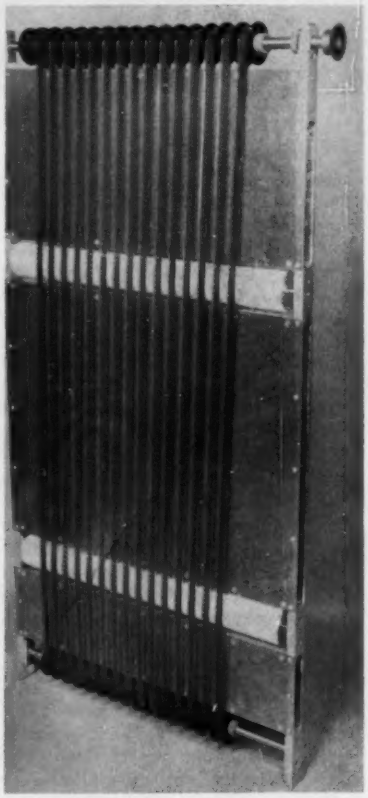

Fig. 7. Center plenum chamber and film rack of the drybox.

Figure 7 shows the center plenum chamber and film rack of the drybox. Two more chambers of the same size fit on either side of the center. Air is received from the riser duct and enters the plenums through the slots in the right end. It is then blown against the film thru 6600 holes which are 0.070 in. in diameter. There is only 83 ft of film on this rack. With a development time of 4 min 30 sec, the drying time is 1

min 15 sec. A total of 1200 w of power is available for heating the air but to date only 600 w has been required to dry film up to speeds of 60 ft/min. The blower has a capacity of 1200 cu ft/min. Although the bottom rollers are an Uscolite to stainless steel bearing operating in drybox temperatures as high as 96 F, there has been no seizing or galling, due to the lubrication of the plastic with Dow-Corning Compound No. 4 which is a silicone grease.

After nearly two years of design and development work followed by several months of testing it can be concluded that the various plastics mentioned in this paper can be suitable for fabrication of practical, low-cost assemblies for color and black-and-white processing machines, which are simple to build and easy to clean and repair.

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Discussion

Glenn E. Matthews (*Eastman Kodak Co.*): What is the principle of the T valve that you mentioned?

Mr. Raymond: The primary purpose of the T valve, or tree valve as we call it, is to permit the cleaning of all pipes, and the transfer of solutions from one tank to another. It was part of our design point of view to keep the number of parts down to a minimum. We'll take the fixative system for example. The solution comes out of the bottom of the fixative storage tank through the lower pipe (see Fig. 3). It goes into the circulation pump and is distributed up into the film rack and tank. From the tank it then flows into the weir tank and out of the bottom of the weir tank into the upper pipe and by siphon action into the storage tank below the level of the solution. Underneath the machine tank is another Uscolite valve which permits complete drainage out of the bottom of the tank into the upper pipe. The upper valve when opened drains this line into the lower pipe or pump line which is controlled by the center valve. With the top and center valves open the solution then drains to a still lower pipe in the system and to a small version of the pumps used for circulation and is returned to the storage tanks. By opening the bottom valve we are able to completely drain the machine and lines of all solution.

Paul S. Peters (*Motion Picture Advertising Service Co.*): How is your temperature control handled on this machine?

Mr. Raymond: Until now we have been concentrating on the experimental work with the use of plastics. We are planning on adding York sealed refrigeration units controlled by Fenwall Thermoswitches in the machine tanks. The storage tanks in this particular case are the area where the temperature will be changed. Because of the type of pump, the general nature and smallness of the whole system and the lack of heating of the solutions due to friction, we have found that we're not going to require very much cooling capacity.

Anon: Is there a practical limit to the size of the tanks that you can make out of that plastic without extensive stainless steel reinforcing?

Mr. Raymond: Thus far our limited investigation on the tanks makes us think we'll make these tanks in the future out of Fiberglas or Uscolite. The method of manufacturing tanks out of Uscolite is still undetermined. We have done quite a bit of checking into the use of a honeycomb center in a laminated type of tank. We haven't actually accomplished this yet but we have seen a number of things made with honeycomb centers and they are quite strong.

Splicing of Motion-Picture, Polyester Film Base and Standard Acetate Safety Film Base by the Butt-Weld Method

By LEONARD A. HERZIG

An improved method and apparatus for butt-welding and butt-splicing of polyester film base and standard triacetate film base have been developed on the principle of a combination of a controlled heat and cooling gradient applied under pressure within a given time cycle. Butt-welded similar types of bases and a method of butt-splicing by the use of an additional high-temperature transparent adhesive sliver are described, and also the combination of both methods used simultaneously

Film splicing has been a serious problem in the motion-picture field for many years. Difficulties have increased in the past five years, and especially recently with the introduction of the new polyester film base. One of the problems is that polyester base films will not splice properly with cements in use today.

The method of butt-weld splicing introduced into the motion-picture field some years ago under the name Presto-Splicer has been adapted to splicing polyester base materials, with some modifications of the original equipment.

In a previous paper (*Jour. SMPTE, 60:* 181–188, Feb. 1953) the author went into some of the technical details of what was involved in obtaining a satisfactory butt-weld splice on triacetate film. However, many additional factors had to be considered when it came to splicing polyester film. First, it is necessary to provide a precisely controlled heating block which radiates heat in a gradient-type pattern confined in area to very narrow limits. Second, it is necessary to have heater block materials with a cooling gradient capable of returning to the required ambient temperature within a maximum time of three seconds. Of these two factors, it was found that the cooling gradient was of prime importance and took precedence in the designing of the proper heater block. Still an additional factor had to be considered: how to prevent polyester film from adhering to the heater platen so that the platen would still be usable for other types of safety film bases.

It was found necessary to coat the heater platen with a material that would not adhere to the polyester base. This coating had to be thin enough to avoid changing the heat gradient characteristic which it is so necessary to preserve. The coating must also have poor heat conducting properties and be capable of withstanding extreme and sudden changes in temperature. After a good deal of experimenting, it was found that "Teflon" (tetrafluoroethylene) could be coated in a very thin layer on stainless steel and still stand up under the abuse encountered in normal splicing. The thickness of this Teflon coating is less than one thousandth of an inch (0.001 in.).

The welding temperatures of the polyester base films and the triacetate base films are quite different. Where the triacetate base films normally have a high melting point, the polyester base films are relatively lower in their flow point. Because of this, resetting of both the timing and the amperage is needed to make a satisfactory splice on the polyester base materials. Accurate controls are provided for quickly resetting the amperage and the time.

Tensile Data

Polyester and triacetate films were tensile tested on a Scott Tester under various relative-humidity conditions to determine the breaking point of butt-weld splices. The findings were as follows:

(1) Polyester base films broke between 43 and 50 lb.

(2) Triacetate film broke between 58 and 70 lb.

When polyester base film is spliced by the butt-weld method, the orientation of the molecular structure is changed, and therefore cannot maintain the same strength as in its original form.

It appears, however, that triacetate film is affected by humidity to a greater degree than polyester, as noted by the variations shown. The films tested were 35mm and in all cases were coated with standard emulsion. The splices tested proved strong enough to withstand all professional end uses.

Projection Tests

Projection tests were made using an endless loop to determine the durability of the splices under normal operating conditions. Periodic checks were made every 100 projections, and in all cases were still satisfactory after 1,000 projections.

Plasticizer

Heat normally has a tendency to drive off a small portion of the plasticizer in the triacetate film base; to compensate for this the system under discussion has been designed to preplasticize the film automatically prior to splicing. A small percentage of this plasticizer is absorbed by the film, which replenishes the normal loss and avoids any tendency of the heat to dry out the film. In addition to this, the plasticizer also changes the point at which the film base will flow when under splicing conditions.

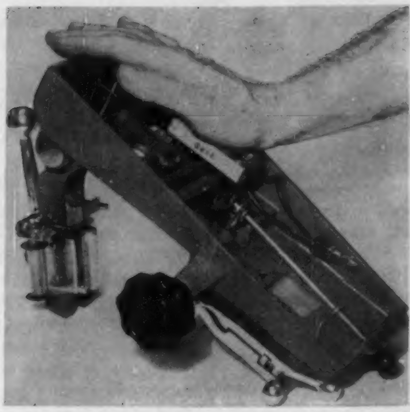
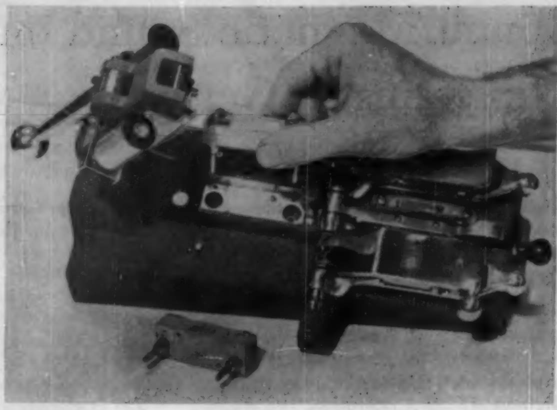
It should be noted here that it was necessary to change the plasticizer formerly used in order to accommodate the polyester base films as well as the acetate base films. Even though polyester base film does not have any plasticizer when it is manufactured, the addition of plasticizer aids in the making of a good butt-weld splice, allowing flexibility and overcoming the brittle effect that heat has on polyester material. The percentage of plasticizer absorbed into the material proved an important factor when running the tensile tests. When over-plasticized, the material has a tendency to elongate prior to breaking and has poorer tensile properties than films plasticized with the proper amount, which withstood 20% to 30% greater stress before breaking. An automatic wick dispenser controls the amount of preplasticizing necessary.

Test splices on triacetate film base were made on positive, negative, magnetic striped, magnetic film, color and black-and-white; whereas the test splices on the polyester base films have been limited to raw stock, print stock and magnetic tapes of various sizes.

Interchangeable Heater Block

Because polyester and triacetate film require very precise temperature control, it is necessary to locate the heater block with extreme accuracy. Formerly, if the heater block required replacement in the field the operator had to center the heater wire to the cut edge of the film by eye. Modifications have been made in the splicers to provide interchangeable "plug-in" heater blocks without the need of adjustments or tools on the operator's part. This is accomplished by using locating pins for positioning the heater block and eliminating

Presented on April 30, 1956, at the Society's Convention at New York by Leonard A. Herzig, Prestoseal Mfg. Corp., 37-27 33 St., Long Island City 1, N.Y.
(This paper was received on April 30, 1956.)

Left, the plug-in heater block is removed from the machine by using the spare block as the ejector; right, the spare block is then placed in position.

all set screws, making the heater blocks interchangeable in less than one minute, and enabling field replacement with factory accuracy.

An unusual splicing problem was presented to us recently: to butt-splice a laminated film composed of triacetate and polyester base material, requiring that we perform a butt-weld splice without any additional bonding agent. Each of the materials was 0.002 in. thick, making a total thickness of 0.004 in. Upon butt-welding the materials, it was found that the triacetate did not contaminate the polyester base, and vice versa, and that each type of base bonded to itself.

Transparent Bonding Sliver

Butt-weld splicing of acetate or triacetate base materials to polyester has not been satisfactorily accomplished without the addition of a thermal bonding sliver acting as a binder for holding the two dissimilar materials together. This thermal bonding material is a polyester film coated with a high-temperature adhesive. Its characteristics are changed once heat has been applied. Various tests were made on sliver sizes using different widths and thicknesses to determine the optimum tensile and flexing strength. Sizes tested ranged in thickness between 0.0015 and 0.003 in., and widths between $\frac{1}{16}$ and $\frac{1}{4}$ in. The optimum size chosen was 0.002 in. by $\frac{1}{8}$ in., even though all sizes were satisfactory in flexing and tensile strength.

The application of this bonding sliver is automatically accomplished by the use of a transfer mechanism which indexes a new bonding sliver into position for each splice. The bonding sliver positioning mechanism is driven by an indexed sprocket wheel moving a perforated tape which carries the sliver into a predetermined position prior to making the splice. The perforated tape releases the sliver during the splicing cycle when under heat and pressure, and the sliver is bonded to the film within two seconds. Tests were made butt-welding the film and applying the bonding sliver at the same time, to find what additional strength could be obtained over the normal butt-weld splice. All of these tests were made on similar base materials. The tensile tests showed that in all cases the film either stretched or broke before the splice showed any signs of letting go.

Pressure Requirements

The normal pressure applied to a butt-weld splice at the time that the film is being welded is approximately 200 psi; therefore, the bonding sliver is compressed into the film, adding only 20% thickness over that of the single layer of film. This is a good deal thinner than standard overlap cement splices and does not create any noise going through a projector's aperture plate.

Under all normal splicing conditions the additional sliver is not required and is needed only when splicing polyester to the acetate base materials or when the splice has to be stronger than the film itself. For this reason, the splicer is not supplied with the sliver dispensing mechanism but the mechanism will be available soon as an accessory.

All Presto splicers can be obtained with a universal heater block which will handle polyester and acetate film.

The splicer has been made for 16mm, 35mm and 70mm film, and magnetic tapes of various widths.

16mm Magnetic Sound on TV Newsfilms in Germany

By ANN-RUTH MARTIN

Official TV programs were initiated only three years ago in Germany and so it was possible to install magnetic instead of optical sound, from the start. Magnetic sound techniques in TV film operation are described.

During the first experimental period after the war, 35mm film was used in German TV film operation, the sound being either optical (combined with the picture on the same film) or magnetic on a separate 17.5mm single-perforated film.

It became obvious for economic reasons that after obtaining satisfactory quality in picture resolution and sound recording, it would be necessary to go over to 16mm film. It was not difficult to decide that magnetic soundtracks should generally be used because of inherent high quality and other operating advantages. This decision was easily made as no optical 16mm sound system had been previously used in the German TV operation. The manufacturing industry developed and provided such equipment as high-quality magnetic recorders for the Auricon Camera, 16mm recorder and re-recorder for edge and middle-track, editing tables, double film check projectors and the necessary accessories. With this available equipment, the whole editing operation from the camera take until the final program transmission is done with magnetic sound.

The method employed varies slightly depending upon the type of picture to be edited. Besides the ordinary feature picture, there are, in general, three types of films in TV production:

(a) Documentary films,
(b) Kinescope recordings, and
(c) Newsfilms.

Work on the documentary film as well as on all short subjects is similar to editing an ordinary motion-picture production. The picture is taken on 16mm film, the sound recorded synchronously on a separate 16mm full-coated film with a 200-mil middle-track located symmetrically to the center line. Commentary or music may be recorded later on a similar track and, working on separate films by intercutting of special or silent shots, it is easily accomplished. This type of picture includes all kinds of short subjects such as educational films, travel films, local or country-wide events, special interviews, etc. With these subjects the editor has time and freedom to produce a high-quality motion picture in which picture quality, editing rhythm and sound balance are essential and the superiority of magnetic sound recording becomes evident.

Newsfilm work is totally different in that time is a critical factor, and the magnetic sound shows its advantages by time saving in editing and processing. The cameras used are Auricon Super 1200, Auricon Cine-Voice and Auricon Pro. A Klangfilm magnetic recorder is substituted for the original optical system and provides excellent sound quality and flutter performance. The single film with magnetic striping, upon which is recorded a standard 100-mil track, normally is reversible-type film. Two hours after this film arrives in the studio, it is processed and ready for editing. The 26 frames difference between the picture and the sound makes editing difficult and intercutting of silent shots impractical. Due to this editing difficulty, the edge track is re-recorded on the previously described middle-track which can be treated together with the original picture film in a manner similar to standard motion-picture editing and can be cut and spliced independently.

After editing, special music, sound effects or a commentary recorded on a 16mm middle-track, disk records, or a commentator speaking live while watching the projected film are added in a mixing process. After all the editing and dubbing is completed, the 16mm middle-track type of magnetic recording is re-recorded on the striped magnetic track of the original picture film which, of course, had been previously erased. This technique makes it advisable to use magnetic edge striping on the film used in non-recording or silent picture cameras when working on the same subject with the combined camera.

The time schedule for a 1000-ft 16mm newsreel shows approximately the following steps:

Delivery of processed film to studio	2 hr
Re-recording on 200-mil middle-track	$\frac{1}{2}$ hr
Editing	2 hr
Re-recording on 100-mil edge track, including dubbing	$\frac{1}{2}$ hr

A total of five to six hours is required from the time the undeveloped negative

Presented on April 20, 1955, at the Society's Convention at Chicago for the author, Ann-Ruth Martin, c/o Südwestfunk-Fernsehen, Baden-Baden, Germany.
(This paper in first draft received April 5, 1955.)


Fig. 1. Editing table for 16mm film.


Fig. 2. Close-up, showing optical and magnetic scanners.

arrives in the studio until the final edited newsfilm is available for broadcast.

There are, of course, news items which can be handled in a shorter time when there is none or very little editing work necessary. This can materially reduce the lapsed time from the exposed negative to broadcast time.

The editing table (Fig. 1), as well as the 16mm standard projector with an optical sound system, are provided in addition to the magnetic playback facilities because for some time to come, some sound effects and other materials will be available on optical soundtracks.

The third type of picture being produced in television studios is the kinescope recording. The editing procedure of these films is similar to the documentary films, the sound being recorded from a microphone or other sources on the magnetic 200-mil middle-track. The kinescope recordings are on black-and-white negative film as several prints are normally needed for distribution to different TV stations. After editing the kinescope program, the middle-track recording is played back and re-recorded on the striped edge track of the picture film.

This paper was not presented to describe the different and, in the most part ingeniously designed equipments, but to show from an editor's point of view that 16mm magnetic sound recording should be used in a TV film operation for its high quality and other advantages. The desirability of visually seeing the soundtrack is not as essential as we have all believed in the past. It is a matter of training to become accustomed to this technique. A long experimental period and nearly two years of official program transmission have proved the superiority of the magnetic sound not only in TV newsreels, but in documentary and kinescope recordings as well.

There is still room for improvements, of course, but the complete magnetic sound chain has achieved a stable performance in our TV film operation.

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motion-picture standards

Six American Standards

Published on the following pages are six American Standards, including revisions of three existing standards, approved by the American Standards Association in April, 1956:

PH22.9-1956—16mm Film Perforated Along Two Edges, Usage in Camera (Revision of Z22.9-1946)

PH22.10-1956—16mm Film Perforated Along Two Edges, Usage in Projector (Revision of Z22.10-1947)

PH22.48-1956—Picture Printer Aperture for Contact Printing 16mm Positive from 16mm Negative (Revision of Z22.48-1946)

PH22.88-1956—Magnetic Coating of 8mm Motion-Picture Film

PH22.97-1956—200-Mil Magnetic Sound Record on 16mm Film Base, Perforated One Edge

PH22.101-1956—Magnetic Coating of 16mm Film Perforated Along Both Edges

A history of the development of the above-mentioned standards accompanied their trial publication in the Journals indicated below:

Ph22.9 and PH22.10—July 1955
PH22.48 and PH22.101—April 1955
PH22.88—March 1955
PH22.97—May 1955

All but two standards, PH22.9 and PH22.48, have been modified since their trial publication. However, in all instances these modifications were editorial in nature, consisting of diagram changes, tabulation of dimensions, addition of scope and numbered formal specifications, change in title or some combination of these.—*Henry Kogel*, Staff Engineer

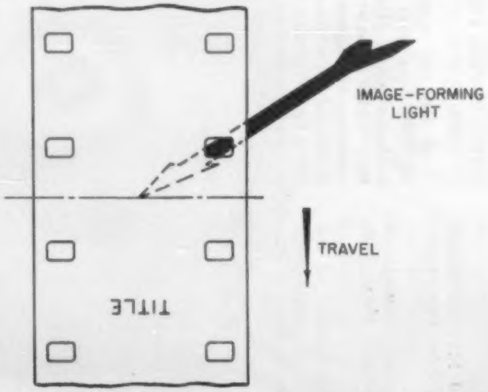
AMERICAN STANDARD

16mm Film Perforated Along Two Edges, Usage in Camera

ASA
Reg. U.S. Pat. Office

PH22.9-1956
(Revision of Z22.9-1946)

UDC 778.534.771.031.3



Drawing shows film as seen from inside the camera looking toward the camera lens.

1. Position of the Emulsion

1.1 Except for special processes, the emulsion shall be toward the camera lens.

2. Rate of Exposure

2.1 The normal rate of exposure shall be 16 frames per second.

APPENDIX

(This Appendix is not a part of the Standard.)

Section 2.1 giving the normal rate of exposure as 16 frames per second is in apparent contradiction with Section 2.1 of PH22.10 which specifies a normal projection rate of 18 frames per second. In modern 16mm practice, however, 16mm film perforated along two edges is used primarily in the amateur field; cameras designed for the amateur are usually spring wound, portable, and not closely governed in taking speed. Variations from 18-14 frames per second at least are commonly observed. It is not customary to design amateur projectors which will reproduce exactly the taking speed and as a matter of fact it has been found that for amateur cinematography this exact speed reproduction is not necessary. Projection at 18 frames does not detract objectionably from films exposed at 16 frames or even at 14 frames and it has the advantages discussed in PH22.10-1956, 16mm Film Perforated Along Two Edges, Usage in Projector.

Therefore, the camera speed of 16 frames per second is regarded as an aim to which considerable tolerances will normally apply. Pictures taken in cameras having this speed tolerance, as well as pictures taken in cameras having constant-speed motors governed at 16 frames per second, will show some change in the velocity of movements when projected at 18 frames per second, but this is not considered objectionable.

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Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U.S.A.
ASA¾M656

Price, 25 Cents

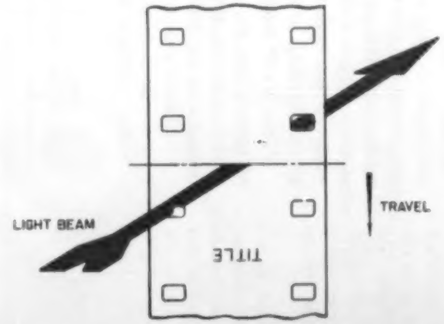
AMERICAN STANDARD

16mm Film Perforated Along Two Edges, Usage in Projector

ASA
Reg. U.S. Pat. Office

PH22.10-1956
(Revision of Z22.10-1947)

*UDC 778.534.771.531.3



Drawing shows film as seen from the light-source in the projector.

1. Position of the Emulsion

1.1 Except for special processes, the emulsion shall be toward the projection lens. This applies to direct projection on a reflecting screen. If a translucent screen is used, or if the image is reversed left for right by other optical features, the film can be turned around so that the emulsion is toward the projection lamp.

2. Rate of Projection

2.1 The rate of projection shall be 18 frames per second.

NOTE: In projectors having a fixed rate of projection, the projection rate shall be 18 frames per second with a tolerance appropriate for the use to which the projection at this rate is to be put. Projectors having manually adjustable speed shall be capable of reaching a projection rate of at least 18 frames per second.

APPENDIX

(This Appendix is not a part of the Standard.)

In modern 16mm projection practice the use of film perforated along two edges is primarily confined to the amateur field. This equipment is usually portable, the available screen sizes are frequently limited with many common screens small in size and of high gain, and many of the projectors have a high light output. Under these conditions it has been observed that frequently very high screen brightnesses are obtained and that the audience is usually aware of flicker before they are aware of changes in the pictorial quality of the projected pictures. It has been industry practice, therefore, to extend the flicker threshold by choosing as high a projection rate (and, therefore, as high a flicker frequency) as is practicable. A projection rate of 18 frames per second and a corresponding flicker frequency of 54 cycles per second (obtained with a 3-blade shutter) has been found by experience to be an acceptable compromise.

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Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

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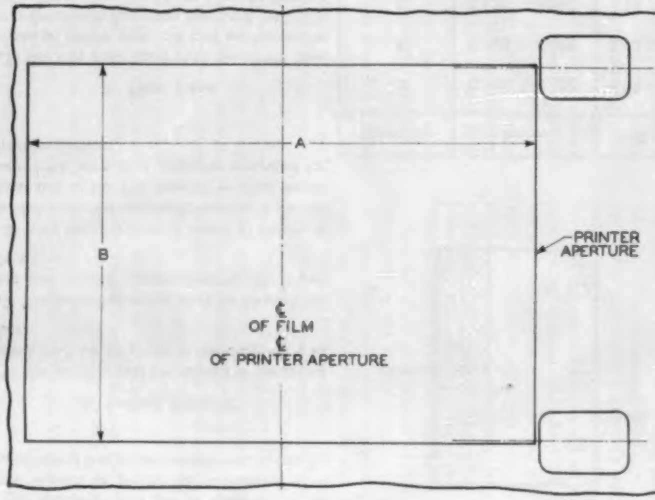
ASA¾M656

Price, 25 Cents

AMERICAN STANDARD

Picture Printer Aperture For Contact Printing 16mm Positive From 16mm Negative

ASA
Reg. U.S. Pat. Office
PH22.48-1956
(Revision of Z22.48-1946)
*UDC 778.5



DIMENSIONS	INCHES	MILLIMETERS
A	0.409 ± 0.003	10.39 ± 0.08
*B	0.306 ± 0.002	7.77 ± 0.05

*This dimension is only applicable when using this aperture for contact printing by the step process.

Aperture corners may be rounded with a radius of 0.020 inch or less.

Approved April 24, 1956, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U.S.A. ASA⅝M656

Price, 25 Cents

AMERICAN STANDARD

Magnetic Coating of 8mm Motion-Picture Film

ASA
Reg. U.S. Pat. Office
PH22.88-1956
*UDC 778.5:771.531.551.2

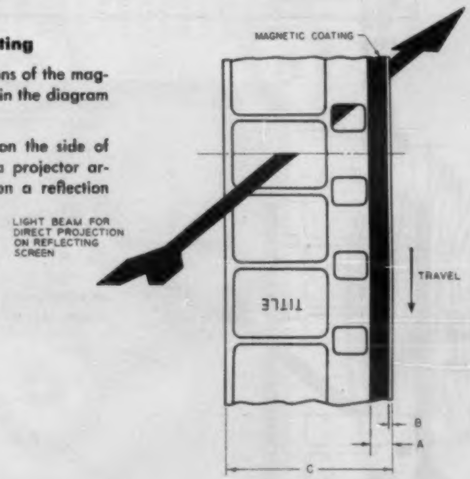
1. Scope

1.1 This standard specifies the location and dimensions of the magnetic coating material applied to 8mm motion-picture film to be used for both picture and sound.

2. Magnetic Coating

2.1 The location and dimensions of the magnetic coating shall be as given in the diagram and table.

2.2 The magnetic coating is on the side of the film toward the lamp of a projector arranged for direct projection on a reflection type screen.



Dimension	Inches	Millimeters
A	0.031 max 0.028 min	0.79 max 0.71 min
B	0.002 max	0.05 max
C	0.315 nom	8 nom

Approved April 24, 1956, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U.S.A. ASA⅝M656

Price, 25 Cents

AMERICAN STANDARD

200-Mil Magnetic Sound Record on 16mm Film Base Perforated One Edge

ASA
Reg. U.S. Pat. Office
PH22.97-1956

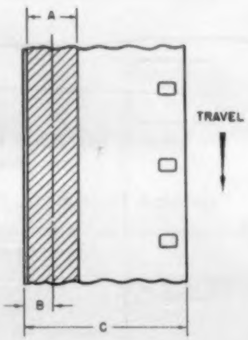
*UDC 778.5:771.531.351.2

1. Scope

1.1 This standard specifies the location, dimensions and recording speed of a 200-mil magnetic sound record on 16mm motion-picture film base with perforations along one edge.

1.2 The film is normally used for sound without picture.

1.3 The dimensions of the magnetic coating is not specified here but is assumed to be wide enough to permit the placement of a sound record in accordance with this standard.



2. Sound Record

2.1 The location and dimensions of the sound record shall be as given in the diagram and table.

2.2 The recording speed shall be 24 perforations per second (approximately 36 ft per minute).

2.3 With the direction of travel as shown in the diagram, the magnetic coating is on the upper side of the film base or in other words toward the lamp on a projector arranged for direct projection.

Dimension	Inches	Millimeters
A	0.200 ± 0.002	5.08 ± 0.05
B	0.103 ± 0.002	2.62 ± 0.05
C	0.630 nom	16 nom.

3. Film Base

3.1 The film base used shall be of the low-shrinkage safety type, cut and perforated in accordance with American Standard PH22.12-1953, Dimensions for 16mm Film, Perforated One Edge.

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Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Price, 25 Cents

AMERICAN STANDARD

Magnetic Coating of 16mm Film Perforated Along Both Edges

ASA
Reg. U.S. Pat. Office
PH22.101-1956

*UDC 778.5:771.531.351.2

1. Scope

1.1 This standard specifies the location and dimensions of the magnetic coating material applied to 16mm motion-picture film with perforations along both edges to be used for both picture and sound.

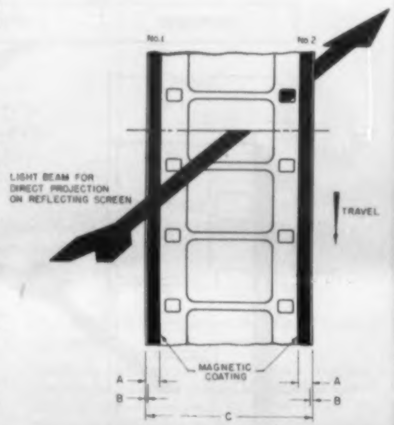
2. Magnetic Coating

2.1 The location and dimensions of the magnetic coating shall be as given in the diagram and table.

2.2 The magnetic coating is on the side of the film toward the lamp of a projector arranged for direct projection on a reflection type screen.

2.3 The No. 1 magnetic stripe is intended for the sound record.

NOTE: The No. 2 stripe is an optional balance stripe and may be a magnetic coating or another material of the same thickness.



Dimension	Inches	Millimeters
A	0.031 max 0.028 min	0.79 max 0.71 min
B	0.002 max	0.05 max
C	0.628 nom	16 nom

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Price, 25 Cents

news and reports

79th Convention – New York

After a two-and-a-half year absence from New York—we last met there in October, 1953—the Society held its 79th Convention at the Statler Hotel, April 30–May 4. Since that last New York meeting the scope of Society activities has broadened and industry interest in SMPTE has grown accordingly.

In 1953, 632 registrants attended 11 technical sessions at which 53 papers were presented. Main emphasis at that 74th semiannual meeting was on wide-screen techniques, 3-D and stereophonic sound. At the 79th, attendance was 1,200, a record for New York conventions. There were 20 technical sessions, including 80 papers, and emphasis had swung to television subjects. Half the sessions dealt entirely with television, with particular attention paid to studio lighting and film commercials, and its influence could be seen in many of the other sessions.

More than 180 Society members took advantage of the advance registration procedure. Total registration included more than 700 members weekly, 128 members daily, 70 nonmembers weekly, 195 nonmembers daily, and 90 ladies. In addition to coming from 26 states in the U.S. and the District of Columbia, registrants also represented nine other countries, including Australia, Canada, England, France, Germany, Holland, Japan, Switzerland and Venezuela.

Responsible for compiling the extensive papers program was Ben Plakun, assisted by eight topic chairmen including Skip Athey, TV General and Educational; Herb Barnett, Underwater Television; Willy Borberg, Motion-Picture Projection, Production and Viewing; Hank Gurin, TV Studio Lighting; George Lewin, Sound Recording; Bill Morris, TV Film Commercials; Bill Rivers, Lab Practice; and John Waddell, High-Speed Photography. Arrangements for the motion-picture short subjects that began each session were made by Ed Stifle.

Taking advantage of the New York location, the committee supplemented the papers program with tours of NBC and Du Mont TV studio installations, and a special screening of *Oklahoma!* in Todd-AO.

General convention planning was efficiently and effectively handled by the Convention Vice-President, Byron Roudabush. The numerous advance preparations and daily duties which contribute to a smoothly run convention were capably completed by the Local Arrangements Chairman, George Gordon, and the local committee chairmen and members.

Preparations for the equipment exhibit were begun by Everett Miller, Exhibit Chairman, some six months before the convention, and his early planning produced excellent results. Thirty-one exhibitors displayed the latest developments in motion-picture and TV equipment, and one exhibitor featured a collection of historical equipment.

Dr. Albert W. Trueman, Canada's Film Commissioner, is greeted by SMPTE President John Frayne at the 79th Convention Get-Together Luncheon.

Advance registration eliminated much confusion at the hotel; nevertheless Kern Moyse, Registration Chairman, and his assistants were kept constantly on the go. Marie Lucas put her Lake Placid experience to good use and efficiently set up and oversaw the registration desk. And Bill Reddick, taking on many more than the usual Auditor's duties, gave willingly and extensively of his time and abounding energy. Also assisting with registration were Emmett Salzberg, Hal Persons, Jack Bower, Ray Fellers, Walter Haas and Bill Koch.

A great deal of advance planning went into making the 79th a success. In addition to program and exhibit arrangements, many of the hotel, luncheon and banquet details had to be completed before the convention got underway. Overseeing these duties were Frank Marx, Luncheon Chairman, Clay Adams, Banquet Chairman, and Saul Jeffe, Hotel Arrangements Chairman.

Three hundred and eighty attended the get-together luncheon at which Dr. Frayne discussed "Motion Pictures and TV — Inseparable Media." Dr. Frayne cited the long history of cooperation in this Society between motion-picture and TV engineers, starting in 1923 with presentation of the first television paper read before the Society by C. Francis Jenkins, the Society's founder. Dr. Frayne also said:

"On the commercial side of the film industry, however, the development of television on a large scale was less gracefully received and an informal cold war was engaged in by both sides. The new and formidable competition presented by television came at a time when pictures of wartime quality had about run their course, and these two influences, which were combined quite by accident, sharply depressed the nation's boxoffice receipts.

"We now find, however, that a number of differences have been reconciled and that there has come about a meeting of the commercial minds in both industries. It is not to be considered abnormal, however, that development of compatible business relationships has followed by ten to fifteen years the meeting of the technical minds."

The Society's president continued, reporting that at the 13 conventions since 1950, when the Society officially broadened the scope of its activities to include television, 50 of 173 technical sessions have been devoted exclusively to TV subjects. He also noted that two SMPTE engineering committees deal entirely with TV studies, including the development of TV standards and the production of TV test films; some 25% of all papers published in the *Journal* are concerned with television; and the David Sarnoff Gold Medal is awarded annually by the Society for technical contributions to television.

Canadian Film Commissioner Speaks

The guest speaker at the luncheon was Dr. Albert W. Trueman, Canadian Film Commissioner and Chairman of the National Film Board of Canada. Talking on

"The Documentary Film—Communicating Experience," Dr. Trueman noted that because of its flexibility and the variety of subjects it can treat, the documentary film is a potent instrument for extending and enriching individual experience. Such an educational tool, he said, can be extremely valuable in a democratic society. He emphasized his theme as follows:

"A democratic society must engage in the ceaseless task of enlarging and enriching the experience of its individual members. I developed this generalization to remind you that our people as a whole will go forward pretty well in proportion to what they know and what they have experienced; that in the long run, understanding and sympathy are based, partly at least, on knowledge and experience; that the documentary film, artistically and honestly produced, can help in the performance of this great democratic task because of its flexibility and the variety of subjects it can treat, and because, intelligently used, it is a teaching and information tool of great value."

Special Events

At a special luncheon on Wednesday, May 2, for TV studio lighting engineers at the Belmont-Plaza, Jo Mielziner, well-known stage designer and theater specialist, discussed the relationship between the artist and the technician in producing and lighting a successful stage or television production. Charles Shelvin was chairman of this luncheon committee.

The 400 who attended the traditional banquet on Thursday evening, May 3, danced to the music of Howard Lanin's orchestra and witnessed the presentation of a citation to Boyce Nemec, who recently resigned as Executive Secretary, for his ten years of service to the Society. Details of this presentation appeared in the May *Journal*.

With 20 technical sessions, many of them concurrent, the projection and public address and recording services were very demanding. But in spite of the tight schedule, these tasks were successfully handled without a hitch. For this we can thank the Projection Chairman, Harry DeFuria; the Public Address and Recording Chairman, Ed Schmidt; and their able and untiring crews. Handling the projection duties from IATSE Local 306 were Steve D'Inzillo, Max Kessler, Gus Cohen, Manny Gessin and Milton Olshin. The recording crew included Larry Knees, Bill Woglom, George Bassett and Richard Gorski of Reeves Soundcraft; Edward P. Ancona and Alfred Ulmer of RCA; Bill Koch and Ray Wulf of Eastman Kodak; and J. Van Deursen and Richard Cook of du Pont.

Three sessions, the TV Studio Lighting on Tuesday and the two Sound Sessions on Thursday, were held at Fine Sound Studios where Bob Fine and Elmer Wilschke were the perfect hosts. Robert W. Eberenz, Chief Maintenance Engineer for Fine Studios, provided special services including recording, and Manny Gessin was the projectionist with the varied equipment required.

Dispensing hospitality in the form of TV tickets, sightseeing discount passes, maps and guides to New York City was Charlie Seager, ably assisted by Paul Christman also of Ansco. And at the Membership Desk Joe Dougherty distributed literature, answered queries and brought in 33 new members. His assistance came from Jack Du Vall, National Membership Chairman, Anita Iavarone, Joe Aiken, Jim Moses, Jack Bower, Charles LoBalbo, Ed Warnecke, Ronald Ringler, Martin Rich, Hal Jones and Herb Farmer.

And lending a willing hand wherever it was needed was Administrative Assistant Harold Jones.

Planning for the ladies' program, which included a fashion show and luncheon at the Waldorf Astoria, a tour of Lever Bros., lunch at Sardi's, and a visit to the Metropolitan Museum of Art, was done by Jack McCullough, Mrs. George Gordon and Mrs. Everett Miller. They were assisted by a committee made up of Mrs. Herbert Barnett, Mrs. John McCullough, Mrs. William Rivers, Mrs. Victor Salter and Mrs. Ethan Stifle.

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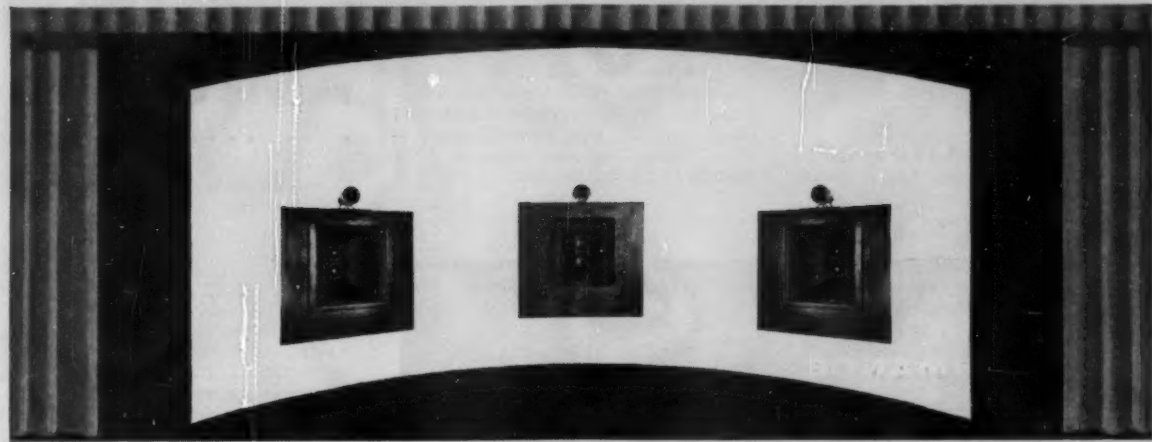

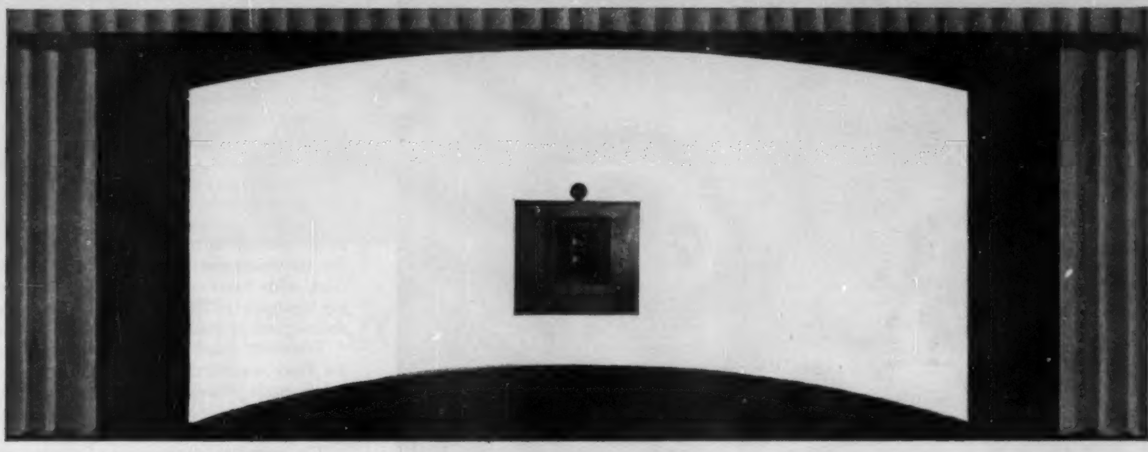

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"The Documentary Film—Communicating Experience," Dr. Trueman noted that because of its flexibility and the variety of subjects it can treat, the documentary film is a potent instrument for extending and enriching individual experience. Such an educational tool, he said, can be extremely valuable in a democratic society. He emphasized his theme as follows:

"A democratic society must engage in the ceaseless task of enlarging and enriching the experience of its individual members. I developed this generalization to remind you that our people as a whole will go forward pretty well in proportion to what they know and what they have experienced; that in the long run, understanding and sympathy are based, partly at least, on knowledge and experience; that the documentary film, artistically and honestly produced, can help in the performance of this great democratic task because of its flexibility and the variety of subjects it can treat, and because, intelligently used, it is a teaching and information tool of great value."

Special Events

At a special luncheon on Wednesday, May 2, for TV studio lighting engineers at the Belmont-Plaza, Jo Mielziner, well-known stage designer and theater specialist, discussed the relationship between the artist and the technician in producing and lighting a successful stage or television production. Charles Shelvin was chairman of this luncheon committee.

The 400 who attended the traditional banquet on Thursday evening, May 3, danced to the music of Howard Lanin's orchestra and witnessed the presentation of a citation to Boyce Nemec, who recently resigned as Executive Secretary, for his ten years of service to the Society. Details of this presentation appeared in the May *Journal*.

With 20 technical sessions, many of them concurrent, the projection and public address and recording services were very demanding. But in spite of the tight schedule, these tasks were successfully handled without a hitch. For this we can thank the Projection Chairman, Harry DeFuria; the Public Address and Recording Chairman, Ed Schmidt; and their able and untiring crews. Handling the projection duties from IATSE Local 306 were Steve D'Inzillo, Max Kessler, Gus Cohen, Manny Gessin and Milton Olshin. The recording crew included Larry Knees, Bill Woglom, George Bassett and Richard Gorski of Reeves Soundcraft; Edward P. Ancona and Alfred Ulmer of RCA; Bill Koch and Ray Wulf of Eastman Kodak; and J. Van Deursen and Richard Cook of du Pont.

Three sessions, the TV Studio Lighting on Tuesday and the two Sound Sessions on Thursday, were held at Fine Sound Studios where Bob Fine and Elmer Wilschke were the perfect hosts. Robert W. Eberenz, Chief Maintenance Engineer for Fine Studios, provided special services including recording, and Manny Gessin was the projectionist with the varied equipment required.

Dispensing hospitality in the form of TV tickets, sightseeing discount passes, maps and guides to New York City was Charlie Seager, ably assisted by Paul Christman also of Ansco. And at the Membership Desk Joe Dougherty distributed literature, answered queries and brought in 33 new members. His assistance came from Jack Du Vall, National Membership Chairman, Anita Iavarone, Joe Aiken, Jim Moses, Jack Bower, Charles LoBalbo, Ed Warnecke, Ronald Ringler, Martin Rich, Hal Jones and Herb Farmer.

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lenticular film. The use of this type of black-and-white film for color recordings is especially desirable, he said, from the point of view of cost, film speed, and the quick and simple processing required. He described several methods of producing images on the film without the use of color filters and pointed out that copies of the kinescope recording can be produced on any suitable subtractive color film through the use of a special printer.—*George T. Negus*, Eastman Kodak Park Works, Bldg. 65, Color Technology Div., Rochester 4, N.Y.

The Northwestern Section met on May 15 at Redwood City, Calif. Approximately 150 persons were present at the dinner and 250 attended the tour through Ampex Corp. Speakers and the subjects presented were: P. L. Gundy of Ampex Corp., "General Aspects of TV Tape Recorder"; W. Goldsmith, "TV Tape Demonstration"; Russ Tinkham, "Broadcast Automation and Tape Duplicator"; Hal Hummel, "Theater Equipment"; Jim Bowles, "Data Recording Equipment"; Art Foy. "Stereo Sound Demonstration." J. G. Frayne, SMPTE President, and E. W. Templin, Chairman of the Pacific Coast Section congratulated the Northwestern Section and Ampex on TV tape accomplishment.—*R. A. Isberg*, Secretary-Treasurer, 2001 Barbara Dr., Palo Alto, Calif.

books reviewed

Fundamentals of Television Engineering

By Glenn M. Glasford. Published (1955) McGraw-Hill Book Co., 330 W. 42 St., New York 36, N.Y. 642 pp. Illus. Graphs. 6 × 9 in. Price $12.75.

This is a textbook covering the fundamentals of television circuit and system engineering. It contains chapters devoted to components peculiar to television, like pickup tubes, which are intended to enable the reader to apply these components.

The opening chapters contain a discussion of the characteristics of the eye, a short course in colorimetry, and scanning theory. Three following chapters on electron beam scanning, image pickup tubes and picture tubes are intended to familiarize the reader with the characteristics of components used in present-day U.S.A. A chapter on pickup tubes, which gives scant attention to types used in Europe, provides a nice compact treatment of noise in input circuits.

The five following chapters are devoted to an analysis of the circuit components of the television system; that is, video amplifiers; wide band r-f amplifiers; an interesting treatment of signal circuit problems and techniques; scanning circuits; and timing.

Transient analysis is given by means of La Place transform methods. Only limited use is made of this method throughout the text, hence, those not familiar with it will not be greatly inconvenienced.

The essential components of a television system, namely, sync generators; camera and camera control; transmitters and receivers are covered in one chapter each. The treatment here is for the most part specific; that is, a circuit, or unit such as the video section of a camera control unit, or a helical transmitting antenna is illustrated and discussed. The treatment of color in these sections is sketchy. Studio distribution problems and techniques are ignored.

The reader who uses this book as a reference may have to dig a bit if he wishes to design, say a video amplifier from the information presented. He may feel that the treatment for d-c restorers and clamps is a bit detailed for the conclusions drawn, in comparison to the light treatment given the difficult subject of automatic frequency control. However, the book serves its primary purpose as a textbook at system level, rather than as a reference book on component design. There is a large amount of material relating to the design of television circuitry, gathered here under one cover, which will be valuable to anyone involved in system or circuit design.—*Robert V. Anderson*, General Precision Laboratory Inc., Pleasantville, N.Y.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1956 MEMBERSHIP DIRECTORY.

Active (M) Associate (A) Student (S)

This is the second list of New Members supplementing the April Journal, Part II, Directory.

Adams, Paul Joseph, Asst. Chief Engineer, KETC. Mail: 6429 Cates, St. Louis, Mo. (M)

Antinheimo, V. A., Meritullinkatu 16, Helsinki, Finland. (A)

Archer, Frank Raymond, Sales Engineer, Sylvania Electric Products, Inc. Mail: 75 Choate La., Pleasantville, N. Y. (M)

Ashla, Mason L., Univ. So. Calif. Mail: 1910 N. Van Ness Ave., Los Angeles 28. (S)

Bard, Carleton L., Jr., Cambridge Sch. Mail: 37 Second Ave., Port Washington, N. Y. (S)

Bayless, Hugh, Fenn Coll. Mail: 1640 Compton Rd., Cleveland Heights 18, Ohio. (S)

Bruce, John Alywin, Avondale Studios Pty., Ltd. Mail: No. 5 Plunkett Td., Mosman, N.S.W., Australia. (M)

Burlin, Edgar M., Pres., Andre Debrie of America, Inc., 1947 Broadway, New York 23. (M)

Calderin, Jose Miguel, Chief Lab. Techn., Community Education. Mail: Box 432, San Juan, P.R. (A)

Cohen, Lawrence G., City Col. N.Y. Mail: 55 Nagle Ave., New York 40. (S)

Cousens, Clayton Worth, Film Producer, Clayton W. Cousens Prod., Inc. Mail: 149 Hill Park Ave., Great Neck, N.Y. (M)

Davis, Edward R., Univ. So. Calif. Mail: 1245 S. Crenshaw Blvd., Los Angeles. (S)

DeLeonardis, Roberto, Vice-Pres., A.C.M.E.S. Mail: Via Della Scrofa 117, Rome, Italy. (M)

Flack, Donald James, Cambridge Sch. Mail: 37 Second Ave., Port Washington, N.Y. (S)

Freeman, Miller L., Univ. So. Calif. Mail: 1446¾ Glendale Blvd., Los Angeles 26. (S)

Godat, Jean Joseph, Mech. Eng., General Precision Laboratory. Mail: 47 Ossining Rd., Pleasantville, N.Y. (A)

Gordon, Cecil S., Univ. So. Calif. Mail: 10535 Almayo Ave., W. Los Angeles 64. (S)

Hallberg, Orville Seth, Asst. Cameraman, Universal International. Mail: 10821 Peach Grove St., N. Hollywood. (A)

Hauser, Arnold David, Student. Mail: 150-15 72 Rd., Kew Garden Hills 67, N.Y. (A)

Henderson, Duncan Gray, Projectionist, Famous Players Corp., Capitol Theatre. Mail: 606 Sunnyside Blvd., Calgary, Alta. Can. (A)

Hornberger, William Peter, M-P Optical & Animation Photo., John Lewis Film Services. Mail: 200 Haven Ave., New York 33. (M)

Hynes, William John, Cameraman, Associated Screen News Ltd. Mail: 5029 Randall Ave., Montreal 29, P.Q., Can. (A)

Kagan, Michael Jakob, City Col. N.Y. Mail: 305 W. 91 St., New York 24. (S)

Kaplan, Fred Alan, Army Pict. Center. Mail: 117 Remsen Ave., Brooklyn 12, N.Y. (S)

Klein, Seymour S., Univ. So. Calif. Mail: 109 N. Alta Vista Blvd., Los Angeles 36. (S)

Lamle, Paul, General Mgr., Grand Central Camera Exchange, Inc., 1 E. 43 St., New York 17. (A)

Laughlin, Robert Lee, Rochester Inst. Tech. Mail: 148 Troup St., Rochester, N.Y. (S)

Lewis, John Hopkins, Mot.-Pic. Process Photo. Mail: John Lewis Film Service, 619 W. 54 St., New York 19. (M)

Lind, Anthony H., TV Engr., Radio Corp. of America. Mail: 23A Wayne Garden Apts., Collingswood, N.J. (M)

Lytle, Chester W., Pres., Lytle Eng. & Mfg. Co. Mail: 316 Hermosa Dr., SE, Albuquerque, N.M. (M)

McBride, Lorne E., Eng., CKCK TV. Mail: 1371 Princess St., Regina, Sask., Can. (M)

McCanick, Everett Mitchel, Univ. So. Calif. Mail: 123 Manhatten Ave., Hermosa Beach, Calif. (S)

McCarthy, Joseph Vincent, Rochester Inst. Tech. Mail: 207 Plymouth Ave., S., Rochester, N.Y. (S)

Macondray, Stewart A., Recording Eng., W. A. Palmer Films, Inc., 611 Howard St., San Francisco. (M)

Mancine, Larry, Univ. So. Calif. Mail: 6052 W. Maryland Dr., Los Angeles 36. (S)

Meeussen, Louis Achille, Head Tech. Dept., Gevaert Co., Gevaert Cy., Mortsel, Belgium. (A)

Merson, Thomas J., Vice-Pres., Audio-Video Recording Co. Mail: 39 Pond Rd., Kings Point, N.Y. (M)

Moshlak, Milton, Studio Mgr., Easten Film, Inc. Mail: 70-30 Parsons Blvd., Flushing 65, N.Y. (A)

Norton, Richard Sheridan, Sound Eng., Warner News, Inc., 33 W. 60 St., New York. (M)

Ober, Wallace George, Supvr. Photo., U.S. Steel Corp. Mail: 2524 Milford Dr., Pittsburgh 34, Pa.

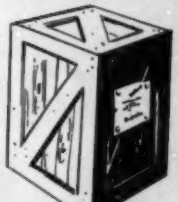
O'Neil, Kenneth Vincent, Film Tech., Cathedral Films, Inc. Mail: 14923 Addison St., Sherman Oaks, Calif. (M)

Ovillet, Melle Jeanne, Directeur Technique, 6 Blvd., Bineau (S.T.O.P.), Levallois Perret, France. (A)

Peterson, John Robert, Lab. Techn., Wilding Picture Prod. Mail: 2296 Magnolia St., Des Plaines, Ill. (A)

Petry, Stanton H., Chief Eng., W. M. Welch Mfg. Co., 1515 N. Sedgwick St., Chicago. (A)

Phillips, Jack Louis, Univ. So. Calif. Mail: 241 S. Crescent Dr., Beverly Hills, Calif. (S)
Rockwell, Charles B., III, Technical Dir. & Pres., Rockwell Films, Inc., 26 Church St., Cambridge 38, Mass. (M)
Rosensweig, Morris, Quality Film Lab. Co., 450 W. 56 St., New York 19. (A)
Shaffer, Hyman, Industrial Sales Mgr., Smith Photo. Mail: 15 Glezer Rd., Newton, Mass. (M)
Shelly, Leon, Pres., Shelly Films Ltd., Brockhouse Rd., Toronto 14, Can. (M)
Smith, James Gilbert, U.S. Army. Mail: Army Pict. Center, 9440 TU, 35-11 35 Ave., Long Island City, N.Y. (A)
Sweeney, Hartwell Townes, Mot-Pic. Film Tech., Eastman Kodak Co. Mail: 90 Buffard Dr., Rochester 10, N.Y. (M)
Sweet, William J., Cine Tech. Repr., E. I. du Pont de Nemours & Co. Mail: 248 W. 18 St., New York, N.Y. (M)
Tamblin, Hal L., Univ. So. Calif. Mail: 140-K S. Fairfax, Los Angeles 36. (S)
Tasker, Hardwicke S., Pres., Ilford, Inc., 37 W. 65 St., New York 23. (M)
Tata, Bufjor, Cine Tech., Rajkamal Kalamandir Ltd., 37 Altamount Rd., Bombay 26, India. (A)
Taylor, Gordon Robert, Eng., 126 Park La., Hayes, Middlesex, Eng. (A)
Taylor, Harold E., Univ. So. Calif. Mail: 2232 Cross St., La Canada, Calif. (S)
Thomas, David Alfred, Cameraman, Universal International. Mail: 4600 Alonzo, Encino, Calif. (M)
Truesdell, Theodore H., Chief Eng., D. B. Milliken Co. Mail: 441 N. Grove St., Sierra Madre, Calif. (A)
Uzoff, Vitaly, Cameraman-Director, Free-Lance, 611 W. 141 St., New York 31. (A)
Van Duyn, Gerard, Art Dir., CKNX-TV. Mail: Josephine St., Wingham, Ont., Can. (A)
Vervoort, Ray Wesley, Film Technician, C. Hunt Co., Mail: 504 N. San Vicente Blvd., Hollywood. (M)
Wasser, George L., City Col. N. Y. Mail: 1845 Phelan Pl., Bronx 53, N.Y. (S)
Weiss, Harry, Recording Eng., Audio-Video Recording Co. Mail: 68–72 136 St., Flushing 67, N.Y. (A)
Weituschat, Fred H., Sound Specialist, U.S. Army. Mail: 21-15 33 St., Long Island City, N.Y. (A)
Werner, Alfred Fischer, Elec. Eng., T. J. Wolff & Co., Inc., 480 San Luis, Manila, P.I. (A)
White, Robert F., Supvr. Broadcast Coordination, National Broadcasting Co. Mail: 85 Perry St., New York. (A)
Williams, Raymond Andrew, Control Instruments Maintenance, Eastman Kodak Co. Mail: 13285 Montague St., Pacoima, Calif. (A)
Wismer, Albert Paul, Cambridge School of TV & Radio. Mail: 6818 Elliot Ave., Maspeth, L.I., N.Y. (S)
Wolf, Richard, Mot.-Pic. Soundman, IATSE Local 52. Mail: 55 Ellwood St., New York 40. (A)
Worster, Robert V., Quality Control Inspection, Eastman Kodak Co. Mail: Box 250, R.D. 2, Topanga, Calif. (A)
Wright, Melvin F., Mot.-Pic. Cameraman, Eastman Kodak Co. Mail: 207 Plymouth Ave., S., Rochester 8, N.Y. (A)
Yarbrough, George Johnston, Electronic & Photo. Tech., Radiation, Inc. Mail: 5220 Hermosa St., Orlando, Fla. (A)
Young, Robert Milton, Mot.-Pic. Cameraman, Free-Lance, 511 E. 20 St., Apt. 12E, New York 10. (M)
Yugala, H. R. H. Bhanu, Business Pres. of Asvin Pictures, Asvin Palace, Rajavidhi Rd., Bankok, Thailand. (M)
Ziemke, Arthur H., Sound Eng., Atlas Film Corp. Mail: 3942 N. Troy St., Chicago 18. (M)
Zorbas, Steven, TV Eng., WQED. Mail: 178 Marsden St., Pittsburgh, Pa. (M)
Zukor, Adolph, II, N. Y. Univ. Mail: 35-11 35 Ave., Long Island City, N.Y. (S)



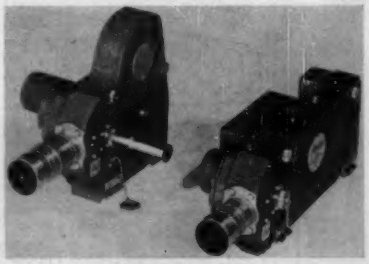
new products
(and developments)

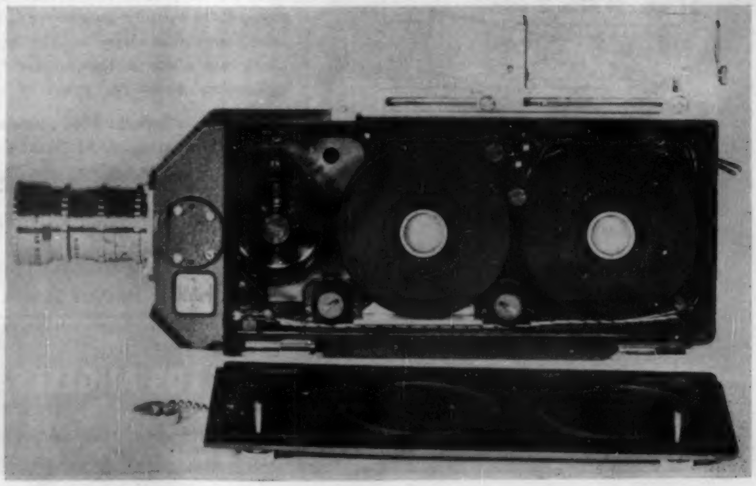
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Fairchild Motion Analysis Cameras (industrial model, HS 101, at left; and aerial model, HS 100, at right) were announced and displayed at the recent Society Convention in New York by Fairchild Camera and Instrument Corp., Industrial Camera Div., 88-06 Van Wyck Expressway, Jamaica 1, N.Y. The aerial model is also shown here, opened for inspection. Of 10 to 11 lb in weight and 11 × 4½ × 4 in. and 7 × 6½ × 8½ in., respectively, the cameras take 100 ft of film on daylight-loading spools. Speeds are 32 to 5000 frames/sec, depending on motors chosen. There are four choices of motors and also choices of take-up spindle and main-drive assemblies which are outlined in a 12-page specifications digest prepared by the manufacturer. The motor normally supplied is a 28-v, d-c unit for a speed of 100 to 1000 frames/sec. Auxiliary high-speed equipment provided is: (1) optical — lenses, extension tubes, boresight finder, fiducial marker; (2) tripods; (3) lighting equipment — stands, lamps, focusing spots, exposure meter, hi-lo switches, schlieren system; (4) control equipment — camera and event timer, camera and event timer with rectifier, programmer; (5) power supplies — batteries, rectifiers; (6) analyzing equipment; (7) carrying cases; (8) miscellaneous — 200-ft spools, 400-ft spools, daylight projector screen; (9) timing-light generators.

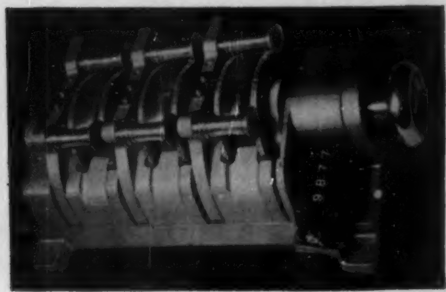
A new 8-page catalog featuring instrument-type switches is announced by Cinema Engineering Co. Aerovox Division, 1100 Chestnut St., Burbank, Calif. Illustrations, a complete code system outline and complete specifications are included in the data. Production switch parts are prefabricated to ensure speedy production, but all Cinema Engineering switches are custom-built. Cinema has a special facility department for heavy-duty industrial type solenoid operated rotary tap switches. Other switches are available with special terminal boards, dust-covers, ball-bearings, stainless steel shafting, coin silver contacts, special detent positions and high voltage construction. For switches requiring more than eight decks, additional decks may be gear driven to achieve the equivalent of 32 decks.

The American Microwave Corp. is a newly organized electronics firm located at 11754 Vose St., North Hollywood. It is engaged in design, development and manufacture of television studio video equipment, microwave systems and custom electronic equipment to specifications.





SYNCHRONIZER HEAVEN

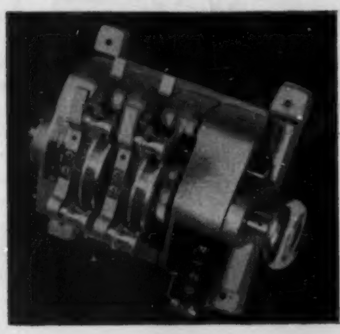


35mm 3-Way Synchronizer $165.00

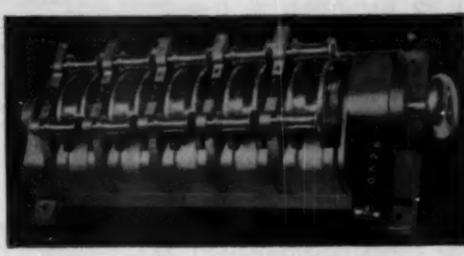
1. Fastens to roller arm of synchronizer.
2. Sync dailies quickly without using editing machine.
3. Ideal for checking sound track for words or effects to be replaced.
4. Fastest and most accurate in locating beginning and ending of words.
5. Tape head can be slid up and back to read a track in any position of fullcoat or magnastripe.

Selling Price:

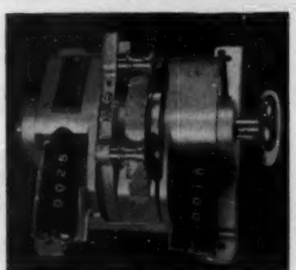
HFC Magnetic Tape Reader Synchronizer attachment	$34.50
HFC Magnetic Tape Reader Amplifier	55.00
Complete Unit	89.50



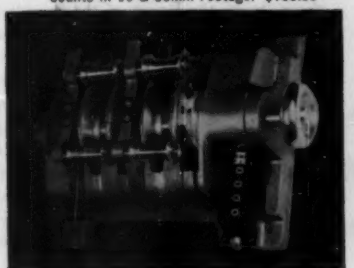
16mm 2-Way Synchronizer $125.00



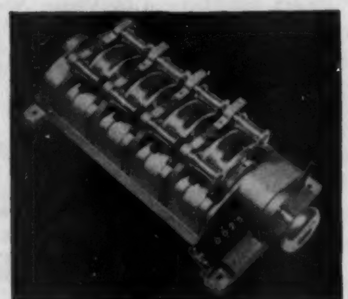
35mm 5-Way Synchronizer $225.00



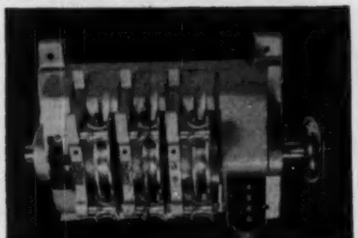
16mm Special Measuring Machine. Counts in 16 & 35mm Footage. $160.00



35mm 2-Way Vistavision Synchronizer with Footage & Frame Counter $160.00



35mm 4-Way Synchronizer $190.00



16mm 3-Way Synchronizer $165.00

65-35mm Combination Synchronizer $380.00

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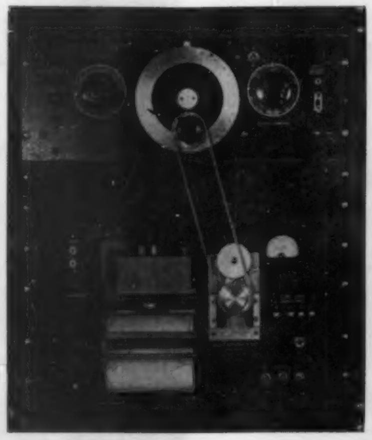


The SL-4 Recorder, manufactured by the Sound Apparatus Co., Stirling, N.J., was designed especially for the plotting of frequency-response curves of electroacoustical apparatus. The response curves of loudspeakers, microphones, filters, equalizers or transformers are plotted fully automatic in a minute or two. The illustration shows a recorder coupled to a General Radio Beat Frequency Oscillator for making frequency-response measurements. It is also possible to operate sound, wave, noise and vibration analyzers in conjunction with the SL-4 Recorder in order to produce a continuous permanent record of phenomena under investigation.

Two recently developed oscilloscopes are among the new instruments listed in the Hewlett-Packard Catalog Supplement 22-A. The 130A Low Frequency Oscilloscope is claimed to be especially useful in evaluating complex voltages. The 150A High Frequency Oscilloscope is used as a general purpose laboratory instrument for fast circuit work in pulse applications such as radar, television, nucleonics and guidance systems. The catalog supplement may be obtained by writing Hewlett-Packard Co., 170 E. 80 St., New York 21.

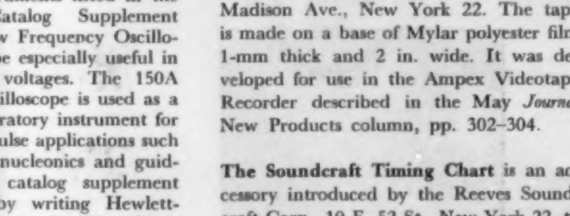
The Varian Model G-10 Graphic Recorder, manufactured by Varian Associates, Instrument Div., 611 Hansen Way, Palo Alto, Calif., has been announced as a moderately priced instrument for recording phenomena capable of representation by d-c signals in the millivolt range. The G-10 utilizes the automatic null-balancing potentiometer principle. It is suitable for local or remote recording. The basic Recorder has 100-mv span, 2.5-sec balancing time, grounded input circuit and one-speed chart-drive unit. Positive-going input signals cause upscale (left-to-right) pen travel. Alternate options are available. The basic price is $295.00.

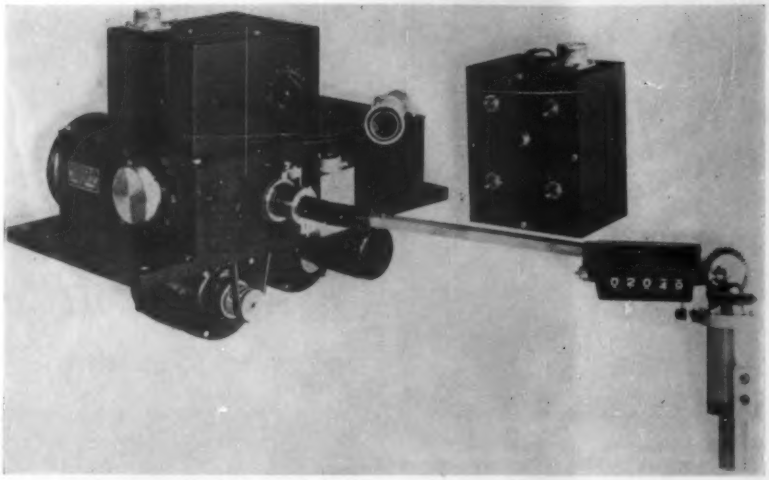
The "Acoustic Gate" principle is used in a 680A dynamic microphone produced by the Altec Lansing Corp., Dept. SE-6, 9356 Santa Monica Blvd., Beverly Hills, Calif. The microphone is designed with a peripheral sound entrance channel of 2-mil width, providing an acoustical resistance loading, virtually independent of frequency to the front of the diaphragm, thereby eliminating high-frequency peaks and extending the smooth frequency response over an unusually high range. This microphone is claimed to lessen the effects of wind, water, dirt or weather.

The Minnesota Mining and Manufacturing Co., Dept A6-114, St. Paul, Minn., has issued a 12-page technical data booklet covering physical and magnetic properties of Scotch brand magnetic tapes and films. The booklet, available upon request, covers such physical properties as backing thickness, ultimate tensile strength, yield strength, elongation at break, residual elongation, tear and impact strength and coefficient of expansion. Magnetic properties include coercivity, retentivity, coating thickness, erasure characteristics, bias current requirements, relative low-frequency output and relative high- and low-frequency sensitivity.

TV-Audiotape, a new magnetic tape designed for recording both television picture and sound, will be produced and distributed by Audio Devices, Inc., 444 Madison Ave., New York 22. The tape is made on a base of Mylar polyester film 1-mm thick and 2 in. wide. It was developed for use in the Ampex Videotape Recorder described in the May *Journal* New Products column, pp. 302–304.

The Soundcraft Timing Chart is an accessory introduced by the Reeves Soundcraft Corp., 10 E. 52 St., New York 22, to enable the user to determine the time and length factors used in tape recording. The chart is especially helpful in planning and programming recorded broadcasts, and in determining the length of tape needed for short commercial and spot announcements. The Timing Chart is semi-logarithmic and enables the recordist to tell, before he starts, how much tape he will need to record for a certain period of time or how long a tape will last him at any recording speed. The need for such a chart has been increased by the introduction of long-play and extra-long-play tapes. The Soundcraft Timing Chart sells for $1.20, available through dealers.



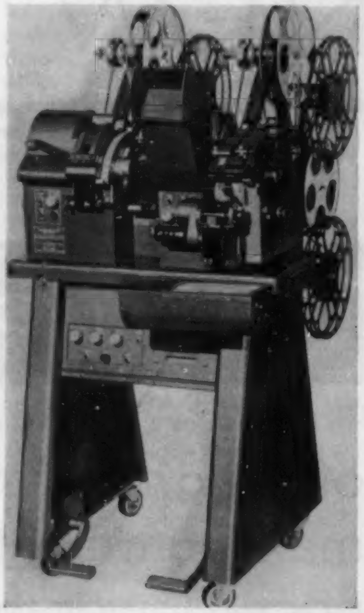


New stop-motion motors have been designed by John Oxberry and are distributed by The Animation Equipment Corp., 38 Hudson St., New Rochelle, N. Y. The five-speed motor is shown above, with the frame counter and right-angle drive at right. The forward speeds are 60, 120, 180 or 240 rpm. They can be changed, without stopping. The rewind speed is 720 rpm (one-half live-action speed), chosen to save a great amount of time rewinding for double exposure and dissolves. Counter and camera are mechanically engaged at all times, to let the operator know which frame is being exposed at any instant. Four forward speeds permit a greater choice of lens stops and the 180 and 240 speeds save time on long continuous camera runs for titles and similar work; the 60 rpm speed is for slow stock (color).

Rapid changeover from single-frame to continuous operation is accomplished through a switch on the floor-mounted control panel. Another switch on this panel changes motor rotation instantly for forward or reverse operation. For stop-motion work, start, stop and rewind action is controlled by means of a foot pedal or by a pushbutton on the control panel.

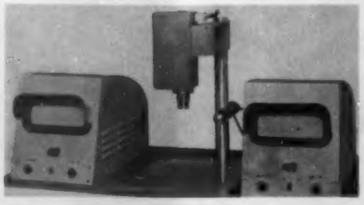
Two-speed motors are built for forward speeds of 60, 120, 180 or 240 rpm in combination with a rewind speed of 720 rpm. One-speed units are available for the same forward speeds but do not have the fast rewind feature.

Background mood music for dubbing on 16mm films or for using with slide films or documentaries can be found in tremendous variety in the 1956 catalog of Thomas J. Valentino, Inc., 150 W. 46 St., New York 36. Industrial firms who make their own sales presentation films can now have access to this library and clearance for dubbing rights can be arranged through Valentino's. The music is on 10-in. records which operate at a speed of 78 rpm and have a frequency of 50 to 8000 cycles. They sell for $2.00 each.



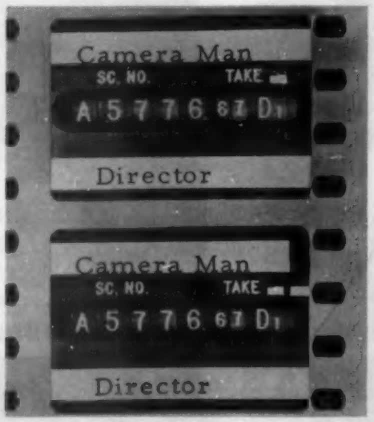
The Edimac, a film editing machine that can run both 16mm and 35mm sound and picture simultaneously, has been developed by J. G. McAllister, Inc., 1117 No. McCadden Pl., Hollywood 38. The Edimac is claimed to run negative film with absolute safety and to simplify such operations as marking, retouching and rewinding. One mechanical electric hand brake controls both picture and sound heads. The machine also runs 17½mm magnetic.

RCA has developed a new power supply unit for use with television studio equipment that is reported to reduce tube and space requirements by more than 70%. The new power supply (WP-15) designed for both commercial and closed-circuit television applications. One of the new features of the unit is dual-chassis construction to simplify installation. It consists of a rectifier chassis, containing all rectifier and filter elements, and a regulator chassis, incorporating the six-tube complement and regulating elements. The new power supply unit will soon be available commercially, RCA announced and will sell for $675.00.



The Dage Data-Vision System, a product of the Dage Television Div., Thompson Products, Inc., Michigan City, Ind., consists of a "slow-sweep" vidicon data camera, a data control monitor, which establishes the electrical operating characteristics of the system, and a data receiver remotely connected, by radio or telephone line, to the output terminals of the data control Monitor.

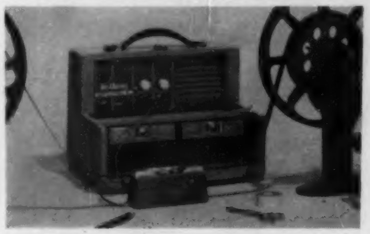
The Data-Vision System permits immediate inspection and distant reproduction of still pictures, maps or records. A complete picture is scanned and traced on a distant radar-type receiving tube in from 2 to 7 sec. Picture detail equivalent to from 180 to 400 lines vertically and with corresponding horizontal resolution can be accomplished, as appropriate, depending upon the rate of transmission and the equalization of the line. Records of moderate complexity can be transmitted for 15 miles over lines that are equalized to 8 kc or used to modulate a standard radio transmitter. The front panels of both the control monitor and the receiving monitor are available with two sizes of mask openings, and 2 × 6 in. size for checks or cards, and the 4 × 5½ in. size for larger forms.



The Kinevox Slater, an automatic device developed by the Kinevox Division of Electromation Co., Burbank, Calif., records sound synchronization and slate data with an external pre-setting device and is claimed to save an average of 10 ft of film on every take. The slater includes an adapter for the BNC Mitchell camera and is also adaptable to any 16mm or 35mm motion-picture camera. In operation, the slater is swung into position before the lens before each take. The slater carries its own internal illumination, powered from batteries which are part of the unit, and is controlled by a three-step light control for complete legibility at different lens stops.

The McMurry Magnetic Sound Reader, a product of McMurry Audio-Electronics, 9746 Irwin Ave., Inglewood, Calif., may be used together with any left-to-right 16mm viewer to synchronize magnetic soundtracks and picture with single-frame accuracy. The small reader units, with remote amplifier, can be used in pairs to permit checking synchronization of sound to picture. Threading is straight through, permitting dead sync editing with the picture frame and subsequently dead sync in the synchronizing machine without losing or gaining frames.

Interchangeable guides available for the reader accommodate 16mm magnetic film with either center or edge track, ¼-in. magnetic tape, single or dual track and, on special order, 17½mm magnetic film. An amplifier, reader and one guide may be purchased for $149.50.



The Arri Silver Recovery Plant is a new one just announced by Arnold & Richter, Munich 13, with information also available from Kling Photo Corp., 257 Fourth Ave., New York 10. The equipment is offered in three different sizes, and can be connected to a closed fixing bath circuit with one or several developing machines. It can be installed in such a way that only the surplus of the fixing solution leaving the developing machine will be used for silver recovery. In any case the fixing solution is circulated by means of an agitation pump, supplied with the equipment, which has a capacity of 2½ to 10 gpm. The complete equipment includes: polyvinyl plastic container; geared motor; gear support and anode bearing cross; cathode sheet ring; special anodes; acid-proof agitator pump with base plate and motor; rectifier with switch controls, voltmeter and ammeter, control instruments and relays.

Membership Certificates (Active and Associate members only). Attractive hand-engrossed certificates, suitable for framing for display in offices or homes, may be obtained by writing to Society headquarters, at 55 West 42d St., New York 36, Price: $2.50.

A new production studio for TV films is nearing completion by Artransa Pty. Ltd. at French's Forest, a suburb of Sydney, Australia. Planning was begun three years ago; films are expected to be in production there this August. Australia's TV stations anticipate general transmission toward the end of this year.

The new studios cover 20 acres and house all departments of film production operation. The initial investment is 300,000 pounds. The two sound stages are each 75 ft × 50 ft with a minimum ceiling height of 35 ft. One sound stage will be equipped with the "flying batten" type of lighting and the other with the "grid" type of lighting. They are equipped with Mitchell cameras for 35mm shooting. Auricon cameras, specially adapted for the Multicam system, will be used for the continuous shooting of half-hour programs in 16mm. Rear-projection equipment also will be available.

The make-up and wardrobe departments are located near the sound stages and are connected by a covered passageway. The art department includes an animation section. An Oxberry Optical Printer, manufactured by The Animation Equipment Corp., will be used for the special effects frequently used in television commercials. A special effects studio will be available for "stop motion" production, including the animation of puppets and specialized photography of models and miniatures.

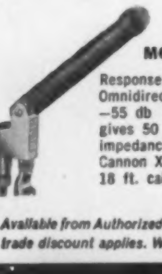
The sound-proofed dubbing studio measures 30 ft × 20 ft. In addition to dubbing sound, the studio is also equipped as a viewing stage. A control room at one end of the dubbing studio features a ten-channel mixing console and accommodates control operators and producers directing sound recording, dubbing and re-recording operations. Also built in is a sound-proof narrator's booth for the "single voice under" type of dubbing. The projection room located on top of the control room will be equipped with both 35mm and 16mm projection facilities.

The new service will offer facilities on a completely independent basis to all advertisers, advertising agencies, television stations and production companies.

Consultant on the project is Rudy Bretz whose earlier international consulting services have been in Germany and Canada. Before going to Australia, Mr. Bretz was consultant to the Alabama Educational TV Commission. Author and co-author of several books, his most recent contribution to the *Journal* was "Televising a Symphony Orchestra" in May 1953.

A 24-page brochure describing the facilities to be available to TV film producers has been released by Artransa Pty. Ltd., 132–8 Phillip St., Sydney, N.S.W.

A high intensity carbon for motion picture projection has been developed by National Carbon Co., 30 E. 42 St., New York 17. The improved 10mm × 20-in. positive carbon is recommended for operation at 95 to 110 amp and is claimed to give 11% more light at maximum current than the previous carbon did at its maximum current rating of 100 amp. At a given current rating the new carbon burns slower in the 95- to 100-amp range.



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Positions Wanted

Audio-Visual Education. B.A. in Industrial Arts Education, formerly Instructor of Motion-Picture Photography, Signal Corps., U.S. Army. Experienced in motion-picture and still photography and TV programming. Background in electronics and high fidelity. Specialist in audio-visual methods and equipment. Complete resume upon request. William J. Ryan, Route 1, Sy Road, Niagara Falls, N.Y.

Motion Picture and Still Photographer. College graduate, B.S. biology. Experienced medical photographer, all phases black-and-white, color scientific photo., with knowledge and use of various cine and still equipment. Varied free-lance assignments. Attending City Coll. N. Y. Film Institute. Desires position with organization in metropolitan New York. George L. Wasser, 1845 Phelan Place, New York 53.

Positions Available

Equipment Sales Representative for inside and outside sales and rentals of professional motion-picture and audio-visual equipment. Thorough experience and knowledge of equipment necessary, must have good sales personality. Write resume, references and salary requirements. Florman & Babb, 68 West 45 St., New York 36.

Equipment Maintenance Man, with thorough experience in Moviolas, amplifiers, projectors, electrical equipment. Write experience, references, salary requirements. Florman & Babb, 68 West 45 St., New York 36.

Audio Engineer. Immediate opening in expanding engineering dept. for man experienced in audio work. Chances for advancement. Complete employee benefits. Please mail details to Personnel Director, Gates Radio Co., Quincy, Ill.

Electronic Engineers. Immediate openings in expanding engineering department for men with experience in fields of TV transmitter and studio equipment, communication transmitters and AM and FM transmitters. Permanent positions, chances for advancement, complete employee benefits. Mail complete details to Personnel Director, Gates Radio Co., Quincy, Ill.

16mm Laboratory Technician for expanding Florida laboratory. Opportunity for supervisor. Must be experienced in maintenance, chemicals, control, processing of black-and-white motion pictures. Color processing experience desired. Write full resume, references and salary requirements to P. O. Box 6474, Jacksonville 5, Fla.

Film Inspectors. Permanent or summer positions open. Telephone or write: Kern Moyse, Peerless Film Processing Corp., 165 W. 46 St., New York 36.

Engineer with knowledge design and installation of film developing machines, control equipment, etc., to act as consultant. Part time initially. Write or phone Paul Klingenstein, President, Kling Photo Corp., 257 Fourth Ave., New York 10, SP 7-3200; representing Arnold & Richter K.G., West Germany.

Sales Engineer, top grade, needed to contact motion-picture studios, labs and government agencies. Experience and know-how of operation of labs, studios and editing rooms helpful. Must be free to travel and have engineering background to sell expanding line of Presto splicers to the trade and government agencies. Unique opportunity for a production man; compensation limited only by ability. Drawing account. Send resume or phone: Leonard A. Herzig, Prestoseal Mfg. Corp., 37-27 33rd St., Long Island City 1, N.Y. STilwell 4-6832.

Cameraman: Duties primarily as 16mm cameraman with some work in sound and editing. College Production unit engaged in producing 16mm color and sound films of an educational nature. Entrance salary $4320/yr. Send resume of background and experience to Norman E. C. Naill, Motion Picture Unit Manager, War Memorial Hall, Blacksburg, Va.

Writer-Editor. Duties primarily as editor and secondarily as writer. Experience in other phases of motion-picture production helpful, but not necessary. College production unit engaged in producing 16mm color and sound films of an educational nature. Entrance salary $4320/yr. Send resume of background and experience to: Norman E. C. Naill, Motion Picture Unit Manager, War Memorial Hall, Blacksburg, Va.

Motion-Picture Unit Director. An unusual opportunity for man to organize and direct a motion-picture unit. He must have experience in animation, slide films and motion pictures. He must be familiar with all types of motion-picture equipment and sources and be able to guide others in the development and execution of industrial training films. Location: St. Louis, Mo.

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News Columns

Advertisers

Meeting Calendar

National Audio-Visual Convention, July 20–25, Hotel Sherman Chicago.

The American Society for Engineering Education, June 25–29, Iowa State College, Ames, Iowa.

National Telemetering Conference, Aug. 20–21, Biltmore Hotel, Los Angeles

Western Electronic Show and Convention, Aug. 21–24, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

Biological Photographic Association, Aug. 27–31, Powers Hotel, Rochester, N. Y.

High-Speed Photography, Third International Congress, including exhibit of high-speed photographic and cinematographic equipment and instrument aids; sponsored by Britain's Dept. of Scientific and Industrial Research, Sept. 10–15, London.

American Society of Mechanical Engineers, Sept. 10–12, Denver.

Theater Owners of America, Inc., Annual Convention, Sept. 19–25, Coliseum, New York.

Canadian IRE Convention and Exposition, Oct. 1–3, Automotive Bldg., Exhibition Park, Toronto, Ont., Canada

National Association of Educational Broadcasters, Oct. 16–18, Atlanta.

National Electronics Conference, Inc., 12th Annual Conference, Oct. 1–3, Hotel Sherman, Chicago.

Audio Fair, Oct. 4–7, Hotel New Yorker, New York.

80th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 8-12, Ambassador Hotel, Los Angeles.

Ninth Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 7–9, Governor Clinton Hotel, New York.

Radio Engineering Show and IRE National Convention, Mar. 18–21, 1957, New York Coliseum, New York

81st Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29-May 3, 1957, Shoreham Hotel, Washington, D. C.

82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 4-9, 1957, Philadelphia-Sheraton, Philadelphia.

83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21-26, 1958, Ambassador Hotel, Los Angeles.

84th Semiannual Convention of the SMPTE, Oct. 20-24, 1958, Sheraton-Cadillac, Detroit.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4-8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6-10, 1959, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1956 Journal.

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SRT Television Studios
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Terrytoons, Inc.
Titra Film Laboratories, Inc.
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United Artists Corporation
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Wenzel Projector Company
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company